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ABSTRACT

Telecommunications research has been focused mainly on technology. Now research about the human factors is crucial. This can be divided into four areas. (1) The needs telecommunications must satisfy--needs can be extrapolated from current behavior. (2) The technological alternatives available--important developments are being made in transmission and switching equipment and user terminals. (3) The effectiveness of the alternatives for meeting the needs--studies should combine the laboratory and outside world and should focus on typical consumers as well as business users. (4) The secondary effects--impact studies are difficult and usually begin after the impact has been felt. An impact study approach can be to ask what constraints would be loosened by the presence of a technological development. For example, lower cost telecommunications would remove one constraint on long distance calls and could lead to new group associations. Several disciplines are relevant to research that is needed, including information theory, management studies, psychology, sociology, urban and regional planning and geography. (MG)

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NEW DIRECTIONS IN TELECOMMUNICATIONS RESEARCH

by

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Abstract

The problem area is defined as that of two-way, person-person telecommunication. Alternative criteria for the future development of the person-person telecommunication system are considered and rejected. It is suggested that future policy must be based on a thorough understanding of telecommunications need, telecommunications technology, telecommunications effectiveness, and telecommunications impact. Methods of tackling each of these problem areas are discussed.

In Part 2 a number of areas of relevant research are described. These include the fields of information theory, applied psychology, experimental social psychology, management studies, sociology, urban & regional planning, and geography. The intention is to demonstrate the general neglect of person-person telecommunications, while describing some of the few directly relevant items of research.

In Part 3 some worthwhile lines of future research are suggested. It is argued that a shift should occur away from technological telecommunications research towards studies of the human aspects of telecommunications. It is also argued that such research should be concerned with the communication problems of the whole community, rather than simply with the needs of business firms.

PART I: CRITERIA FOR TELECOMMUNICATIONS PROGRESS

The problem area

Telecommunication may be classified firstly into one-way (e.g. broadcast) and two-way (e.g. telephone) communication. It may also be classified into person-person, person-machine, or machine-machine communication. This paper is concerned only with two-way, person-person, telecommunication. Moreover it is concerned with such systems not as items of electronic hardware, but as channels of human communication.

By what criteria must the developing system of telecommunications be judged, if it is to play its full part in facilitating human communication? And are we, in the present state of research, capable of applying such criteria?

The technological fallacy

Technological feasibility is a necessary, but not a sufficient criterion for innovation. The fact that a particular telecommunications system, such as the video-telephone, is technologically feasible is no justification for its development (1). It is extremely dangerous to argue that such developments form some kind of 'logical' and even inevitable progression. To take an example from the field of transportation, the fact that civil aircraft have steadily increased in airspeed does not prove that this trend can be usefully extrapolated ad infinitum. At each stage of innovation the probable costs must be weighed against the probable benefits, alternative courses of action being compared on this basis. And of course the great weakness of technology as a strategic criterion is that there always are alternative courses of action, each of them technologically feasible.

In the case of telecommunications, although the video-telephone is technologically feasible, so also is the rapid transmission of paperwork by facsimile (2). Technological feasibility in itself is no guide to the priority which should be attached to each alternative.

Imitation of the irrelevant

Instead of regarding telecommunication as driven on by a technological dynamic, it is possible to regard it as progressing towards the increasingly accurate simulation of face-to-face contact. A difficulty of such an approach is that accuracy exists along many

dimensions (3). Wholly accurate telecommunications would involve an image that was full size, full colour, in three dimensions, and with perfectly reproduced speech. How important are each of these kinds of accuracy, and what is the trade-off between them? There is no simple answer to the question of whether, for example, a full size black and white image is preferable to a small coloured one (4). Some of these aspects of realism may be much more important than others, and some may not be important at all. In specifying a plastic to replace wood in a particular application it would be necessary first to decide what features of wood were important in the context. Slavish imitation of the original might lead to unnecessary and costly reproduction of irrelevant features such as grain and bark.

It must also be borne in mind that an increase in accuracy, particularly if it occurs along a single dimension, will not necessarily lead to an increase in realism, and may even be counter-productive. Experiments in perception show that the brain has a remarkable ability both to sift out the salient features of the signals reaching it (5), and to construct out of these features, however fragmentary and incomplete, a coherent picture of the world. It has been said that the senses do not give us a picture of the world directly; rather they provide evidence for checking hypotheses about what lies before us (6). Attempts at too much realism may frustrate this process. Thus the listener to a radio play may be able to form in his mind an image of the actors which, while innacurate, is far more realistic than any theatrical production with its artificialities of proscenium, scenery and greasepaint. A stereoscopic photograph, which invites us by its imitation of depth to treat it as a real view, creates by its lack of movement an impression of unrealistic stillness which is absent from a two-dimensional photograph (7). Simply to pursue the accurate reproduction of face-to-face contact may therefore be counter-productive as well as unnecessary.

The inferior substitute fallacy

If telecommunications is treated as a simulation of face-to-face contact it is by definition a second best alternative. In fact telecommunications systems have considerable potential advantages over face-to-face contact, advantages which will not be exploited if such systems are treated as inferior substitutes for the real thing. The full potential of plastics was unrealised until they ceased to be regarded as man-made substitutes for natural materials, and were treated instead

as materials in their own right, with their own unique qualities. The most obvious disadvantage of telecommunications, namely that, as in the case of the telephone, it excludes the visual channel of communication may in itself constitute a positive advantage. We seek privacy in a number of ways, in for example the clothes we wear. The businessman in his office, or the lecturer on a platform, will often feel more comfortable if he can take up a defensive position behind a piece of furniture (8). Because, compared with face-to-face contact, the telephone provides a reduced channel of communication, it represents the same kind of privacy shield. And because, unlike the face-to-face visit, the telephone does not invoke the customary associations of host and guest, it is free of the obligations and commitment inherent in face-to-face communication (9).

But the outstanding feature of telecommunication is that it combines in one medium the important advantages of mail and face-to-face communication. Like mail, it is largely indifferent to distance, thus providing an enormous geographical range of potential contact (10). But activities, such as discussion and negotiation, which require the rapid exchange of small packets of information (11), cannot be conducted via a system which inserts such long delays between transmission and reception (12). Such activities can of course be conducted face-to-face. But face-to-face contact requires the participants to be all in the same place at the same time, a constraint which restricts considerably the variety and flexibility of an individual's communication network. The individual may make some limited extensions to this network by travelling, but only at the cost of considerable time and effort. Too much travel may also result in unacceptable damage to the individual's communication network at his base. The ability of telecommunications, therefore, to transmit small packets of information rapidly to a variety of destinations represents a unique capability, which must not be regarded simply as some kind of infer ior substitute for face-to-face contact.

Needs, technology, effectiveness and impact.

Thus neither the pursuit of technology, nor the imitation of face-to-face contact are adequate philosophies on which to base policy for the future development of person-person telecommunications. At the least, such policy should be based on a thorough understanding of the following four factors:

1. What is the pattern of communication <u>needs</u> which telecommunications must try to satisfy?
2. What improvements to telecommunications <u>technology</u> are likely to be feasible, at what date, and at what cost?
3. How <u>effective</u> are such systems likely to be, in terms of satisfying communication need?
4. What secondary <u>impacts</u> would arise from the widespread introduction of such systems?

<u>The pattern of communication needs</u>.

The pattern of communications needs should be the starting point of telecommunications policy, just as the educational needs of the children form the starting point for the design of a school system, or travel needs form the starting point for designing a transportation system. At one level, communication need may be assessed from a thorough knowledge of the existing patterns of communication, although this itself is something about which there is very little information, certainly as compared to the state of knowledge in the analogous field of transportation (13). But at a more general level, the problem of assessing communication need is a complex and intangible one, much more akin to the equally tricky one of assessing educational need, than to the comparatively clear cut matter of personal transport. This is partly because the purposes and process of human communication are singularly difficult to measure and describe (14). The purpose of a trip can usually be categorised fairly easily as the journey to or from work, delivery of goods, shopping etc. The purpose of a communication is more difficult to define; moreover the individual purposes of the various participants in a communication are unlikely to coincide (15). If the problem of categorising the purpose of a communication is difficult, the problem of measuring the extent to which that purpose has been achieved is doubly so. The speed at which a vehicle travels from A to B, and whether it arrives safely, may be unambiguously determined. Whether a communication achieves its purpose, and the rate at which it does so, is a matter of argument rather than measurement (16). But even if the existing pattern of communications can be identified, there will be underlying potential needs for communication to which existing patterns give little clue. This may be because of the limitations of current telecommunications technology, or because the possibilities of the current technology are unexploited. This very natural

inertia in adapting our communication behaviour is an important factor to be reckoned with. Despite revolutionary advances in transmission technology (including satellites and micro-wave links) the telephone still performs the same function, in much the same way, as it did fifty years ago (17). Perhaps one reason for this is that the telephone instrument represents the interface with the human user; innovations which take place beyond this interface, for example in the transmission of the signal, require little or no adaptation of communication behaviour on the part of the user, and can therefore proceed unhindered (18). But public resistance to change in communication behaviour should not be over-estimated. A case in point is television which, perhaps because it demands of the viewer passive acquiescence rather than active participation, was able to transform behaviour patterns in the course of a few years (19). Thus the study of the existing patterns of communication, necessary as it is, is not the whole answer to the question of communication needs. Existing patterns must be treated as the datum from which, in the light of careful analysis of organisational or social goals, future communication needs can be extrapolated.

Improvements to telecommunications technology

Three types of technical innovation are possible within the telecommunication system; innovations in terminal equipment, switching equipment, and transmission equipment. The most important directions in which terminal equipment is likely to advance are towards video communication, and towards data capability. In each case the options are numerous. Video communication may involve moving or still images, the latter being presented either in ephemeral form on a cathode ray tube display, or permanently by means of hard copy facsimile printing. Wide variations in information rate are possible, the usual extremes being those of the telephone channel, as used in slow facsimile systems (approx 3kHz) and the broad band colour television channel (approx 5MHz). This represents a range of over 1:1000 in transmission capacity, and a range of the order of 1:100 in cost. Although their costs may be estimated with some confidence, the lack of information about the likely usefulness of these various systems makes it exceedingly difficult to choose between them. The choice is made all the more agonising by the fact that, because of the large fixed cost of telecommunications plant, such choices once made are very costly to reverse.

The question of data communication is strictly outside the scope

of this paper, but because telecommunications terminal equipment is likely to serve the joint needs of person-person and person-machine communication, it must be touched on here. Person-machine telecommunication terminals require facilities for data input, and data output. The ordinary telephone dial is, of course, a data input device, but for a specific and limited purpose. The limited information rate of the dial (20) may be overcome by moving to a push-button telephone. The most severe limitation of the push-button telephone as an input device is that it cannot conveniently transmit alphabetic information (21); this suggests an eventual move to a full alpha-numeric keyboard similar to a typewriter. An attractive theoretical possibility, which might overtake these developments, is the advent of practicable voice recognition systems which enabled purely verbal person-machine communication (22). This would obviate both the physical need for the keyboard, and the necessity for users to acquire keyboard skills.

As a data output device the ordinary telephone is confined to a few distinguishable audio signals, including the ringing tone and the engaged (busy) signal. Recorded verbal announcements are already in use for engaged (busy) signalling, answering machines, time checks, and weather, shopping and sports information. They have considerable potential as an output channel for machine-person communication (23). The alternative is to incorporate either an alphanumeric or full television display, on which data may be carried. In each case the terminal equipment would be expensive, say between 10 and 100 times the cost of a normal telephone. If however it was capable of short-term storage of the information it received, a display of this kind could operate in conjunction with a telephone or data circuit of comparatively low bandwidth (24). A visual data display system could potentially be extended to the transmission of documents by rapid facsimile, or even the transmission of still or moving images of another person. It is here that the needs of person-person and person-machine communications overlap.

Apart from video communication and data capability a number of other innovations are likely in terminal equipment. One possibility is the provision of a high-fidelity channel for voice communication (25). The difficulties of achieving two-way loudspeaking voice communication are in fact considerable, particularly so if the rooms in use cannot be acoustically treated, and the microphone is distant from the speaker's mouth (26). Another possibility is the expansion of mobile

services; the lowest form of mobility being that of the 'cordless telephone' which could be carried around a room. In the ultimate it is conceivable that an individual would carry a telephone, small enough to be kept in the pocket, worn on the wrist, or even placed inside the ear, which enabled him to communicate freely anywhere. However the practical realisation of such a concept, like that of fully three-dimensional video communication, must await considerable and so far unforeseeable advances in technology.

Innovation in switching systems will have the effect of increasing the capacity and efficiency of the telecommunications system in general, rather than in providing any new services. The purely technological questions which this raises are outside the scope of the present paper. The main implication for the user is that automation will allow the rising cost of labour to be offset.

Innovation in transmission systems, on the other hand, will have an important direct effect on the telecommunications user. Firstly, there is the prospective growth of cable communications, bringing numerous video channels into the home or office. Although present systems, based as they are upon tree-like distribution networks, are suited to the one-way distribution of programming, rather than the conduct of many-to-many conversations, future systems are unlikely to be so restrictive (27). The provision of a return voice or data channel will enable the viewer to select from a wide range of material, and interact with the programmes he selects. Ultimately it will be possible to provide return wideband channels, so that full two-way video communication can occur on a many-to-many multiplexed basis (28).

Secondly, there are the new technologies of satellites, wave guides, and optical fibres. All of these point towards a steady decrease in the cost of long distance transmission. Only a minor part of the cost of a telephone call is attributable to the costs of long-distance transmission of the signal; the bulk of the cost is accounted for by terminal equipment, local distribution, and switching (29). In the case of video communication, however, the costs of long distance transmission predominate over terminal and switching costs, and it is here that the new technologies of transmission are likely to have their most dramatic effect.

There are therefore three possible types of innovation; in terminal equipment, in switching equipment, and in transmission equipment. But another quite different and considerably more important kind of

change is possible. This is a change in the system itself, rather than in the parts of the system: a change from a passive, unintelligent system to an active, intelligent, one (30). At present the telecommunications system is conceived as efficient but wholly self-effacing. I have the potential, sitting at my desk, to lift the telephone and talk to any one of millions of individuals, all over the world. But how do I know whom to contact, and when and where he can conveniently be reached?

Channels and systems

When we think of a device such as the telephone we tend to think of the channel which it represents; a voice channel of approximately 3kHz bandwidth, with defined limits of loss, noise, and distortion. But the system characteristics of the telephone are equally important. The channel characteristics describe the channel through which communication occurs, once that channel has been established. The system characteristics describe the process by which channels can be established. The most obvious system characteristic of the telephone service is its sheer size, as represented by the number of stations served. The utility of a communications system is related to the number of potential links which it represents. This is roughly proportional to the square of the number of stations served, and therefore increases rapidly with the addition of extra stations (31). Where the rate of adding extra stations is accelerating, the rate of increase in the number of potential links is explosive (32). Another system characteristic of the telephone is the existence of telephone numbers, and the printed directories that go with them. And another system characteristic is the vocabulary of signals by which the system communicates with the user. These include the ringing tone and the engaged (busy) singal. But in a more general sense the human intermediaries between the communicators proper are also part of the system. The telephone as a means of social communication is essentially a secondary one, used to maintain contact between individuals who know each other, rather than to initiate new contacts. But in the work context the telephone is used in an exploratory fashion, to identify and track down contacts, as well as to maintain communication with existing contacts. This exploratory activity is only possible because of the human intermediaries in the system. These include the directory enquiries (assistance) operators (33) and the army of switchboard operators within firms. General publication of up-to-date directories

of firms' internal extensions would be an impossible task. Moreover the host of personal secretaries who perform the essential tasks of filtering calls, or taking messages and suggesting alternative times if the contact is not available, should also be considered as part of the telephone system. But despite these human intermediaries (whose continued existence is likely to become prohibitively expensive) the system characteristics of the telephone remain somewhat crude, certainly by comparison with the printed word or face-to-face communication.

The printed word is not only a profuse channel of communication; it possesses a rich variety of means for the user to explore the channel. These include library indexes, anthologies, directories, literary reviews, bibliographies etc. The population of telephone users sitting at their telephones represent a formidable library of information and expertise; yet it is a library whose only index is the telephone directory. And it is a library in which one cannot browse, picking books off the shelf at random.

In system terms the process of face-to-face contact is infinitely subtle. It is because of their profusion and their subtlety that face-to-face contact patterns, which may at first sight appear either random or trivial, play an essential part in forming communities whether at home or at work (34). Where people see a lot of each other the costs and the inconvenience of communication are low; in the great waves of face-to-face communication which slosh about among neighbours and work groups there may be much that is redundant. But embedded in the trivia are those items of informal information and opinion out of which personal relationships are built (35). In the face-to-face condition, unlike the telephone, it is possible to gauge the atmosphere and choose one's moment to communicate. To take the case of communication within offices, the process by which the communication itself is established is subject to wide and subtle variation. The meeting may, for example, be initiated by inviting someone into one's own office, by knocking on, or poking one's head around, his door, by chance encounter in corridor or lift, or by formal pre-arrangement (36). Each creates a different situation, and each is appropriate for a different purpose.

By comparison, then, with either reading or face-to-face contact, the system characteristics of the telephone system are rather crude. Yet the telecommunications system has the potential to be infinitely more intelligent and selective than either reading or face-to-face contact. Given the computational power to store and organise relevant

information about the individuals and organisations which it served, the telecommunications system could play an active role in stimulating effective contact patterns. If the user indicated to the system his general interest or specific information needs, the system could recommend which individuals he should contact, rather as a good librarian recommends books to a reader. Thus, when the telephone rang, it might be not another human but instead the system itself, explaining that it had discovered somebody with whom it thought, from its knowledge of you and its knowledge of him, you would like to talk. Moreover from a knowledge of this individual's general availability, and of the times at which he did not wish to be disturbed, the system could arrange to contact him at a time of the maximum mutual convenience. In this way the telephone system could acquire manners as well as intelligence. The ultimate development of a knowledgeable and intelligent telecommunications system would of course raise important issues of privacy and abuse; given the right safeguards such problems are in principle surmountable.

When a telecommunications device is viewed in this way, as both a channel and a system, it is clear that innovation can occur in either area. Sophistication in one area does not imply sophistication in the other; it may in fact exclude it. Thus the telephone, with its long development history and deep market penetration, has built up comparatively powerful system characteristics (if only in terms of sheer network size) although as a channel it is extremely limited. On the other hand a point-to-point closed circuit television conference system between two studios is sophisticated to the point of extravagance as a channel, but very crude in system terms (37).

The question of the relative priority that should be given to channel or system innovation is one which demands careful analysis of the effectiveness which which devices of given channel and system characteristics satisfy defined communication needs.

The measurement of effectiveness

The results, in terms of effectiveness, of altering the channel of communication may be studied under the controlled conditions of the laboratory. By bringing together pairs or groups of individuals, and connecting them by a variety of channels, including face-to-face communication, closed circuit television, videophone, and telephone, their performance at measurable tasks may be compared (38). The advantage of laboratory experiments of this kind is that they enable

detailed measurement and analysis of communication behaviour, and the repetition of similar tasks via different channels so that statistically valid comparisons can be made. They also enable one to investigate channels, such as closed circuit television, which are extremely expensive to intal over any distance in the field.

However the system characteristics of a device installed in a laboratory are quite different from those which would obtain in the field. Only in field trials, therefore, can the system characteristics of a device be evaluated in terms of effectiveness. This may be done by eliciting subjective attitudes of users towards currently available and prototype communications equipment by questionnaire or interview (39). But without the possibility of repeating similar communication tasks, and measuring communication behaviour in detail, it will be impossible to gather the kind of objective data which is available in the laboratory. This kind of trade-off between rigour and realism is almost inevitable. Its worst dangers can be avoided by making the laboratory experiments as realistic as possible; for example by using as participants samples from the population to whom it is intended to apply the results, and by designing communication tasks which reflect as closely as possible the type of activities in which the participants would engage in real life. Conversely some element of control may be introduced into field experiments by varying the nature of the channel during the experiment; a procedure which is unfortunately almost unreconcilable with the desire, inherent in commercial market trials, to project the new device as powerfully as possible.

Some compromise between the features of laboratory and field experiments may be attempted by a programme of laboratory/field research in which one end of an experimental link is in the laboratory, and the other end in a real organisation. In this way an individual could be removed to the laboratory for a period of weeks, and carry on his job via a telecommunications link which connected him to his work group. Working with a single volunteer in this way it would be possible to monitor his communication behaviour accurately. It would also be possible both to manipulate the channel externally by adding or withdrawing facilities, and to allow the participant to manipulate the channel himself, selecting the telecommunications system which he deemed most appropriate for particular tasks (40).

Given that the strengths and weaknesses of each are largely complementary, a combined programme of experiments in the laboratory

and the field appears to represent the best method of evaluating telecommunications devices as both channels and systems. But even a combined programme of this kind possesses important weaknesses which should not be overlooked. Firstly, there is the sheer problem of size. Apart from the basic variables of the telecommunications device, and the communication task, there are numerous other factors which may have an influence on effectiveness. These include the number of individuals involved; the patterns of conflict or cooperation which exist between them; their absolute and relative status; the extent to which they know each other beforehand; their attitudes towards new technology; and their educational attainment. To explore the effects of each of these potentially important factors would require the participation of several thousand individuals in an experimental design of considerable size.

A second, and more intractable, difficulty centres around the problem of adaptation. It may arguably take a generation for a telecommunications device to be fully assimilated. The deliberate way in which an old person, or one who is unfamiliar with a telephone, approaches the instrument is quite remarkable. But the office employee who has become fully accustomed to the telephone handles it with the same easy familiarity that he would hold a pencil or cigarette. This long process of adaptation by which a new device matures from a curious novelty into an everyday commonplace around which special customs and attitudes have grown up is one which defies simulation in either laboratory or field experiment..

Early warning of telecommunications impact

An enlightened policy of telecommunications innovation demands careful consideration of the secondary impacts which may arise from the widespread introduction of new systems. Failure to foresee these secondary impacts may be commercially and socially damaging, as the example of the automobile demonstrates. To take a commercial case, the financial difficulties of the railways in both the UK and the USA might have been mitigated if proper account had been taken, early enough, of the likely impact on their business of developments in passenger and goods transportation by road (41). Impact studies of this kind must be engaged in as long-term preventative measures. Unfortunately their importance tends to be overlooked until serious symptoms occur, by which stage the interest of such studies is purely historical. As the advertisements say, you cannot join a medical

insurance scheme from your hospital bed.

To take a social case, mounting pollution, congestion, accidents and parking difficulties have finally brought home the fact that the automobile as currenly conceived is ill-suited to the essentially pedestrial layout of most existing cities (42). If this incompatibility had been foreseen early enough, and action had been taken, it would have been possible to adjust the design of automobiles, and the design of cities, to so far as possible reduce the friction between them. And it should have been possible to foresee this incompatibility, if the effort had been made. Neither the technology of automobiles nor the pattern of cities has changed unpredictably in the last fifty years; would that a fraction of the effort which has gone into styling automobiles and buildings during that time had gone into considering the impact of the one upon the other.

In the light of these cautionary tales, how can we predict the likely secondary impacts of future developments in person-person telecommunications? Just as the fundamental characteristic of writing is that it enables communication to occur across time, the fundamental characteristic of telecommunication is that it allows communication to occur, as the word suggests, across distance. Advances in telecommunications will reduce the cost, and increase the effectiveness with which such communication may occur. Let this new development be defined as factor X. One way to predict what changes would occur in the system if X were introduced is to ask oneself whether there are any states which the system is currently inhibited from adopting because of the absence of X. Thus if the absence of X can be seen to be imposing constraints on the existing system, the introduction of X would have the effect of loosening those constraints. In these terms it can be argued that the absence of perfectly cheap and effective telecommunications gives rise to two broad and obverse kinds of constraint, namely the constraint of communication upon distance, and the constraint of distance upon communication.

Communication as a constraint on distance

The costs and inconvenience of communication, whether by face-to-face contact or telecommunication, rise steadily with distance (43). Indeed the process of face-to-face communication requires that the participants be separated by distances of only a few feet (44). It follows that any sub-population whose members wish to achieve face-to-face contact must arrange to be in the same place at the same time. But each individual is in fact a member of a number of such sub-populations,

including his family, his social groups, and his work group. And these groups proliferate and interlock in a series of intersecting sets (45). Thus there is a need for contact between the father and his child, between the child and the paediatrician, between the paediatrician and other paediatricians etc. The need for this kind of face-to-face communication imposes three kinds of constraint upon our activities. It forces us to come together in buildings such as offices, schools and universities, whose primary purpose is to act as nodes for face-to-face communication. It forces these nodes to cluster together in cities so as to reduce the distance, and facilitate communication, between them (46). Finally it forces us to travel between nodes (journey to work, intra-city business travel) and between clusters (inter-city and international business travel) in order to maintain membership of a variety of face-to-face contact groups.

On this basis, it would be reasonable to expect that improvement in telecommunications would lead to a loosening of each of these three constraints. Thus better telecommunications would reduce the need for face-to-face communications nodes, enabling large offices or educational institutions to be broken down into smaller units. It would also reduce the need for these units to cluster together in cities, with consequent advantages in terms of regional development, lower operating costs, and increased amenity (47). Finally better telecommunications might cut into the demand for intra-city and inter-city business travel, by the substitution of electronic communications for physical travel (48). Telecommunication has two main advantages over travel. Firstly, telecommunications is effectively instantaneous. Secondly its costs generally rise less steeply with distance than do the costs of travel. For these reasons the substitution of electronic communication for physical travel is most likely to occur where the demand is for irregular, unpredictable, and urgent communication over long distances. But it is dangerous to assume that better telecommunications will produce a net reduction in the amount of physical travel (49). It will be pointed out below that the net effect may be quite to the contrary.

Distance as a constraint on communication

A number of studies have shown that volume of communication falls off as a function of distance (50). But there seems little inherent reason why the need for communication should fall off in this way. It seems more likely that the way in which the costs of communic.. on

increase with distance acts as a constraint, inhibiting potentially valuable long-distance contact patterns. This situation is self perpetuating, since where the volume of communication is low, the awareness of the need or opportunity for further communication will also be low (51). But if telecommunications improves, and the constraint of distance is weakened, a number of implications follow. Firstly, a general intensification of long distance links could be expected. Such a development would facilitate the development of multi-regional and multi-national organisations in business and government, enabling geographical decentralisation of activities to be accompanied by centralisation of control (52). And a general intensification of long distance links would stimulate all forms of interaction, including physical travel. This tendency would run counter to the possibilities of substitution described above; the net effect of telecommunications on travel is therefore extremely problematical.

Secondly, it is possible that the development of very cheap and very effective global telecommunication would produce a substantial increase in the collective power of human intellect, much as occurred through the invention of printing (53). The electronic computer achieves its performance by means of rapid and effective interaction between innumerable essentially simple cells (54). Indeed, this appears to be equally true of the human brain (55). If, therefore, the human population were knitted together by an exceedingly intense and sophisticated telecommunications network, a collective intellectual system would result whose power was vastly greater than that of its individual parts.

Notes to Part I.

(1) Video-telephone has in principle been feasible for quite a while. Between 1935 and 1938 a television-telephone service was operated by the German Post Office between video-telephone centres in four cities: Berlin, Liepzig, Nuremberg, and Hamburg. To make a video call, the public made appointments in advance to be at the centres at pre-arranged times. Operators made the connections manually with plug-in jacks, the signals being transmitted over coaxial cables. Between 1956 and 1964 studies were carried out at Bell Telephone Laboratories towards the development of a video-telephone for general service. The Mod I Picturephone was demonstrated to the public at the New York World's Fair in 1964. In the same year a limited commercial service was initiated between Picturephone centres in New York City, Chicago, and Washington D.C.

(2) As long ago as October 1948 a demonstration was held at the Library of Congress, U.S.A., in which the entire text of 'Gone with the Wind' was transmitted in facsimile over a television microwave circuit in slightly over two minutes. This represents a rate of 15 to 30 pages per second. (Bond D.S. & Duke V.J. 'Ultrafax', RCA Review, 10, 99, March 1949). Apart from equipment for specialist applications (including the transmission of weather maps and news photographs) an increasing number of manufacturers are producing equipment for the transmission of documents over normal speech telephone circuits. Equipment currently available in the U.K. includes the HELLFAX (Maritronic Ltd.), the SENDOX (Muirhead Ltd.), the DEX-1 and DEX-4 (Computer Instrumentation Ltd.), the DATAFAX 240 (Stewart-Warner Ltd.) and the TELECOPIER II (Rank-Xerox Ltd.). These machines require between 4 and 6 minutes for the transmission of an A4 ($8\frac{1}{4}$" x $11\frac{1}{4}$") document.

(3) Accuracy of reproduction may be considered to exist along the following three main dimensions: 1. Auditory, 2. Visual, 3. Other channels. Where 'other channels' is taken to include the tactile, olfactory, and other channels which escape the eye and the ear. If these three main dimensions are displayed at right angles to each other they create a space such that any communication system may be defined in terms of its position within that space. Certain parts of the space are already achievable by telecommunications; progress may occur along one or more of the three axes. (See figure 1 on page 19 overleaf).

(4) Magazine and newspaper advertising rates act as some indication of one type of trade-off between size and colour in terms of communications effectiveness. A full page advertisement in the U.K. edition of Time magazine currently costs £1975 in colour, £1290 in black and white. This is a ratio of 1.53:1, such that 1.53 square inches of black and white advertising costs the same as 1 square inch of colour. The ratio for the London Times newspaper is similar. In the Times a full page costs £3,600 in colour, £2,640 in black and white; this is equivalent to a ratio of 1.36:1. In the case of domestic television receivers the cost premium for colour is much higher. A typical 22" black and white receiver costs £85 against £290 for a colour receiver of the same size. This is a ratio of 3.41:1.

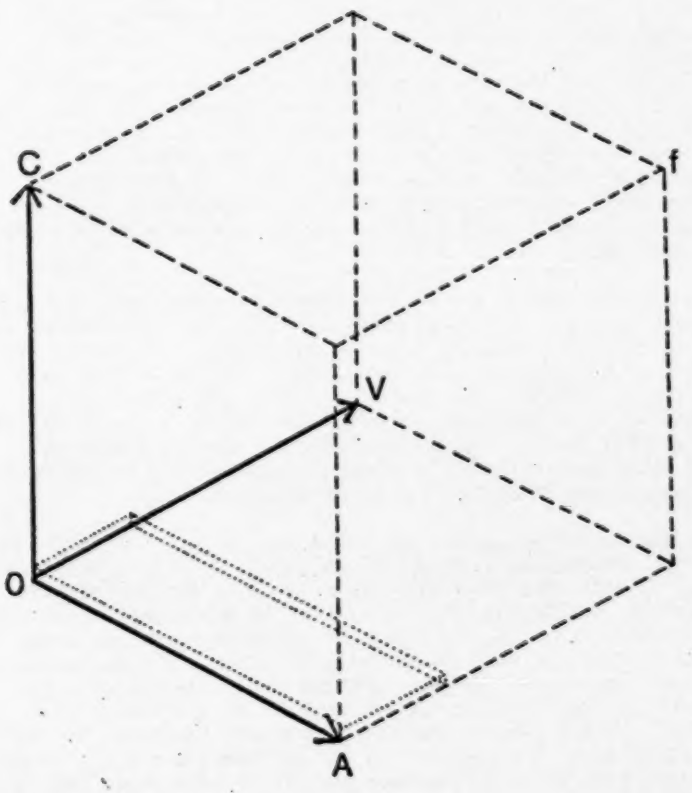
(5) Experiments in selective listening are reviewed by Broadbent D.E. ('Perception and Communication', Pergamon Press, 1958). He concludes that irrelevant information is more easily discarded if it comes from a different place from the relevant material, if it is louder or softer,

Figure 1: Dimensions of telecommunications accuracy

The solid lines represent three axes of telecommunications accuracy, at right angles to each other. OV is the axis of increasing video accuracy; OA is the axis of increasing audio fidelity, and OC is the axis of increasing accuracy of other channels (tactile, olfactory etc.).

All theoretical telecommunications systems may be considered to lie somewhere within the cube bounded by the solid and pecked lines. The boundary of current technology is represented by the dotted line, i.e. totally accurate audio, moderately accurate video, and very low accuracy in the tactile/olfactory channels.

The totally accurate system (point f) may be reached via a number of different routes through the cube. The opposite point, O, represents zero communication.



or if it has different frequency characteristics. A number of experiments by Cherry indicate the listener's ability to sift out the relevant messages. In one experiment Cherry required subjects to repeat back continuously speech heard on one ear alone, and found that they could ignore other irrelevant words on the other ear. In fact the subjects ignored the irrelevant speech so completely that they were afterwards unable to recall in which language it had been spoken. Other similar experiments are described in Cherry C. 'On Human Communication' M.I.T. Press 1957; see also Cherry C. 'The Cocktail Party Problem', Discovery, March 1962.

(6) 'But it seems clear that perception involves going beyond the immediately given evidence of the senses: this evidence is assessed on many grounds and generally we make the best bet, and see things more or less correctly. But the senses do not give us a picture of the world directly; rather they provide evidence for checking hypotheses about what lies before us. Indeed, we may say that a perceived object <u>is</u> a hypothesis, suggested and tested by sensory data' (Gregory R.L., 'Eye and Brain', Weidenfeld and Nicolson, 1966).

(7) This effect is noticeable when scenes are viewed in a simple 'View-master' viewer. When viewed stereoscopically scenes involving people acquire an appearance of frozen, or arrested, motion. The same effect is noticeable, to a lesser degree, in the case of scenes involving trees and foliage.

(8) The use of a desk to maintain visitors at the appropriate social distance is discussed in Hall E.T. 'The Hidden Dimension', Bodley Head, 1966. The way in which furniture is used to defend individual or small group privacy has been investigated experimentally. A number of such experiments are reported in Sommer R. 'Personal Space', Prentice-Hall, 1969; Scheflen A.E. 'The significance of posture in communication systems', Psyciatry 27, 1964; and Hare A.P. & Bales R.F. 'Seating position & Small Group Interaction', Sociometry 26, 1963.

(9) Whereas the face-to-face meeting in business has many of the characteristics of social hospitality, including greeting procedures and solid and liquid refreshment, the telephone call consists more of forcible entry. To quote Hall E.T. ('The Hidden Dimension'), 'There is no wall or door against the telephone. Since it is impossible to tell from the ring who is on the other end of the line, or how urgent his business is, people feel compelled to answer the phone'.

(10) Because the transmission costs of a telephone call consist largely in local distribution and in switching, rather than in long-distance transmission, tariffs typically reach a ceiling quite rapidly. Thus the cost of dialled trunk calls in the U.K. reaches its maximum at 50 miles, although calls may actually cover a distance of several hundred miles. The cost of operator connected international calls from the U.K. reaches an effective ceiling of between 75p and £1 per minute at about 3000 miles. Thus the cost of such a call to Canada or the U.S.A. is 75p per minute (distance varying between 3500 and 6000 miles); the cost to India is £1 per minute (air distance to Delhi 6000 miles); and the cost to Australia is the same (air distance to Sydney 13500 miles). In fact because of a peculiarity of the tariff a 3 minute person-to-person call to Australia is cheaper than a 3 minute person-to-person call to Canada, although the distance may be four times as great. (Charges based on May 1971 tariffs).

(11) Jaffe and Feldstein found that in 30-minute laboratory dialogues, around 190 'speaker switches' would occur. Eight means are given for eight occasions, each mean being based on 72 observations (each of the 24 subjects has three values derived from interaction with three other subjects). The mean number of 'speaker switches' varies between 185.5, and 198.8, equivalent to a mean length of utterance unit of between 9.7 and 9.1 seconds. A speaker switch is 'the interface between the respective monologues into which conversation may be decomposed'. An 'utterance unit' is defined by Fries as 'all the speech of one participant until the other participant begins to speak'. (Jaffe J. & Feldstein S. 'Rhythms of Dialogue', Academic Press, 1970).
D.L.Richards gives a figure of 15 times per minute as the typical rate for participants to alternate the role of speaker in telephone conversations (Richards D.L. 'Communication by Speech - The important factors in telephony' Paper presented for Institution of Post Office Electrical Engineers, 1970.).

(12) Suppose an hour's dialogue consisted of 360 ten second utterances, and that the dialogue were to be carried out by post, allowing 24 hours for the transmission of each utterance between two points in the UK, it would take almost a year for the completion of the equivalent of one hour's dialogue. The cost differential is much less. Thus an hour's dialled peak rate telephone conversation beyond 50 miles in the U.K. costs £4.50, against £10.80 for sending 360 first class letters. (Charges based on May 1971 tariffs).

(13) In the U.S.A., the Detroit Area Traffic Study (1953), the Chicago Area Transportation Study (1956), the Penn-Jersey Transportation Study and the Tri-State New York Metropolitan Transportation Study were the forerunners of the large urban transportation studies supported by the U.S. Bureau of Public Roads. These studies are now so widely accepted that to qualify for financial assistance in road construction, the 213 urban areas of over 50,000 population in the U.S.A. must carry out a continuing, comprehensive land-use/transportation study (Federal Highway Act 1962). Some idea of the scale of these exercises appears in the introduction to the Pittsburgh Area Transportation Study, where reference is made to 'the more than three hundred study employees' who carried out the data collection, coding, processing and analysis.
The first major traffic survey in the U.K. was the London Traffic Survey (1960). Its first three phases are estimated to have cost £1m., although as Bruton points out, this represents only about 0.01% of the total investment required for roads that might be built as a result of the study (Bruton M.J. 'Introduction to Transportation Planning', Hutchinson, 1970).

(14) A number of methods have been developed of observing and categorising interpersonal communication behaviours, but they all require considerable training of observers to produce consistent results.
Bales interaction recording method uses twelve categories of act, including 'shows solidarity', 'shows tension release', 'agrees', 'gives suggestion' etc. This system has been developed to 18 categories by Borgatta. (Bales R.F. 'Interaction Process Analysis', Addison-Wesley, 1950. Borgatta E.F. 'A systematic study of interaction process scores, peer and self-assessments, personality and other variables', Genet. Psychol.Monogr. 65, 1962). Elaborate methods exist for coding non-verbal behaviours. The best known is Birdwhistell's 'kinesics' system; this involves 4 eyebrow positions, 4 eyelid positions, 7 mouth positions, etc., with 33 positions in all. (Birdwhistell E.L. 'Kinesics',

International Encyclopaedia of the Social Sciences, 8, 1968). A similar scheme developed by Kendon involves 7 eye positions, 5 brow positions, 16 mouth positions, 7 head posititons, 2 neck positions, 3 hand and arm positions, 9 shoulder and trunk positions, and 5 gaze directions. But even such a comprehensive system requires sweeping simplifications and generalisations. An indication of the great variety of distinguishable non-verbal behaviours exists in the finding by Gibson & Pick that subjects were able at a distance of 2m. to distinguish an angular deviation of the looker's eyes of about 2.8°. This corresponds to a frontal displacement of the eyeball of 1mm. (Argyle M. 'Social Interaction', Methuen, 1969., Gibson J.J. & Pick A.D. 'Perception of another person's looking behaviour', Amer.J.Psychol. 76, 1963).

(15) This is clearly so of competitive or bargaining communication. But even in co-operative problem solving groups elements of conflict will exist. Bales argues that 'under certain conditions of organization, and when there is a clear-cut but complex task of group decision to be arrived at within a given session, groups tend to move through an orbit of directional movement over the course of the session. They may start with preliminary pleasantries that average toward the positive side. As they begin with the task proper they move downward with high rates of giving orientation, then forward and upward as rates of orientation fall and rates of giving opinion and suggestion rise. The movement tends toward the negative side as giving opinion rises accompanied by disagreement. Some groups, especially those which begin with low status consensus, may hang in this phase indefinitely. Others, particularly if their status problems are not severe, pass through the crisis, and begin to swing back toward the positive side as agreement is reached'. (Bales R.F. 'Interaction: Interaction Process Analysis', International Encyclopaedia of the Social Sciences, 8, 1968).

(16) A number of field communication studies have found that participants in contacts have widely differing perceptions of their occurrence and characteristics. Weinshall, in his survey of 34 managers in the Devon Corporation (5,135 interactions, 1,708 of these within the group, over a two-week period) found that in only 12% of cases was there agreement on the occurrence and nature of the contact. The descriptive categories consisted of giving or receiving a decision, instruction, information, or advice. Of those contacts which were mutually perceived as having occurred, consensus on the type of interaction was obtained in 47% of the cases. (Weinshall T.D. 'The Communicogram' in J.R.Lawrence (ed) 'Operational Research and the Social Sciences', Tavistock Publications, 1966.). Burns, in his 1954 study of activity and communication patterns in a four man executive group over a five week period found that consensus on the subject of the contact was obtained in between 56% and 65% of cases. Consensus on the nature of the contact was obtained in between 59% and 62% of cases. The nature of the contact was described in terms of giving, obtaining, recording, explaining or systematising information; information being divided into decisions, instructions, advice, and information. Burns suggests that 'on many occasions, about one-third of all, the concerns of the two individuals in the same matter were very different - one looking at a particular difficulty as concerned with, say, costs, and another perceiving the same thing as arising from the personnel involved'. (Burns T. 'The Directions of activity and communication in a departmental executive group', Human Relations, Vol.7, 1954). Hesseling, in his studies of communication and organisation structure in Philips N.V., finds considerable dissonance between 'personal internal interaction profiles' ('my reaction to the internal organisation') and

'Internal interaction profiles with me as perceived by others'. He finds that when individuals are presented with these results, the wide discrepancy between their own view of their communication with others, and others' views of their communications with the individual, can be extremely disconcerting to those involved. 'When managers see the implications for a chain of interactions, where the likelihood for (the communication) coming through decreases rapidly indeed, they might jump to conclusions and actions and destroy the carefully balanced operating communications system'. (Hesseling P., 'Communication and organisation structure in a large multi-national company: a research strategy', Paper delivered to conference of the Operational Research Society, London, December 1968).

(17) The telephone has sturdily withstood the rapid functional innovations which have occurred in other fields since 1876. During 95 years in which the motor car, the aeroplane, cinema, radio, television, and the electronic computer were invented, there has been little functional advance in person-person telecommunications systems.

(18) A parallel case is that of the development of synthetic foods. The main problem here has not been that of substituting for the functional (nutritive) qualities of natural foods. The most important marketing criterion is that the synthetic foods should have the texture, appearance, and taste, of the original. Provided that this criterion is met, technological revolutions can occur below the surface. Considerable success in reproducing the texture of meat has now been achieved by spinning protein into TVP (texturized vegetable protein). (Wood J.C. 'Textured Protein Products', Food Manufacture, March/April 1971).

(19) In the eight years between 1949 and 1957, the number of television sets in the United States rose from 4 million to 47.2 million, corresponding to a rise in the figure of sets per household from .09 to .95 (DeFleur M.L. 'Mass Communication and Social Change' in Tunstall J. (ed) 'Media Sociology', Constable 1970).
The average amount of viewing by members of households owning television sets appears to be about 2 hours per day for the population as a whole. U.K. audience research carried out by AGB for the Independent Television Authority gives a figure of 4.5 hours per day for the average amount of time that TV sets are switched on; this would be greater than the amount of viewing per head (AGB Handbook, London 1971). The figure given by the BBC (BBC Handbook) for average amount of viewing by members of households owning television sets is much lower at around 14 to 15 hours per week. This is similar to the figure given for the general population in Greenberg B. & Dervin B. 'Mass Communication and the urban poor', Public Opinion Quarterly, Summer 1970. For their low income sample, however, Greenberg and Dervin found a much higher figure of 5.2 hours per day. By any account it appears that watching television has in the space of a few years become one of the most extensive human activities in developed countries, second only to sleeping, working, and eating.

(20) The run-back time of the telephone dial limits the speed at which numbers may be dialled to an absolute maximum of about 50 digits per minute. This is very slow compared to keyboard speeds; punch card machine operators punching numeric data achieve speeds of between 10,000 and 20,000 key depressions per hour, equivalent to about 250 digits per minute.

(21) The possibility of sending alpha information over numeric keyboards by double-keying has been investigated. Apart from the reduction

in speed which results, complex systems of this kind lead to much higher error rates.

(22) A computer-based experimental voice recognition system developed by British Telecommunications Research, Taplow, operates in the following way. An individual speaks a number of spondees into the system, for example place-names or numbers. Working on this limited vocabulary, and with the same individual, the system is then able to recognise individual spondees when they are repeated. The problem of recognising from a wide vocabulary and a large number of speakers is very much more complex.

(23) The technical problems of recording whole messages for playback over the telephone system (as is done with recorded announcements) are trivial. The next stage of sophistication is to record individual words, phrases, or syllables, which can then be automatically assembled into a variety of messages as required. This type of system is already in commercial use. The greatest flexibility is achieved by systems which generate completely synthetic speech. Work at Bell Laboratories, Murray Hill, during 1970, involved a computer which was programmed with mathematical approximations of the shapes and motions of the human vocal tract. The computer also stored rules of timing, pitch, and stress. In operation, messages were typed and sent to the computer by teletypewriter. The computer then analysed each sentence, assigning stress and timing to words; mathematical descriptions of vocal-tract motions are then computed, from which electrical speech signals are generated.

(24) The Committee on Telecommunications of the National Academy of Engineering, Washington, call for the development of a storage system of this kind in their January 1971 Quarterly Report: 'Basically the terminal would take advantage of the television set and telephone which are already present in most homes and interconnect them with an acoustically coupled storage-display control device. Messages from the user would be entered by way of the telephone handset (touchtone or dial). Information could be received at the terminal either by standard telephone lines or by cable TV distribution. In either case the data is received and converted to the proper format for display on the television set. (Committee on Telecommunications, National Academy of Engineering, 'Communications Technology for Urban Improvement', Quarterly Report to the Department of Housing and Urban Development, February 1971).

(25) High quality voice circuits appear to have been caught in a vicious circle of high cost and low demand. They are widely used for distribution of broadcast radio programmes, but the only organisational use we have encountered is as the sound channel of conference television systems. It is found that in this context, partly perhaps because of the users' familiarity with high quality sound on broadcast TV, the quality of the sound is critical. Pearman reports that in the British Post Office experimental 'Confravision' link, 'The quality of the sound is more important than the vision and raises more problems' (Pearman D. 'Factors affecting satisfactory sound-with-vision conference facilities', Fourth International Symposium on Human Factors in Telephony, Bad Wiessee). Where vision is absent, lower standards of voice quality appear to be acceptable. Thus the Boeing Company's 'Apollo' network uses regular voice-switched voice grade telephone lines for its audio conferences, although the associated facsimile capability operates on a 48kHz circuit. (Wetmore W.C. 'Boeing Network Cuts Apollo Work Costs', Aviation Week & Space Technology, February 10, 1969). The user's attitude towards high quality voice appears to be very much tied up with his expectations;

in a pilot experiment carried out at Bell Laboratories, Holmdel, in 1970, it was found that subjects expressed no clear preference in favour of a telephone which contained high quality components, and was connected via a high quality link.

(26) 'If a distant-speaking microphone is connected through a telephone line to a loudspeaker, the loudness of speech from the loudspeaker can be increased as much as is desired; if, however, a path of the same kind is set up in the opposite direction between the same two locations, oscillation will take place and this can only be prevented by restricting the total gain round the complete loop. Without any voice-switching it is just possible to establish acceptable both-way loudspeaking telephone communication in this way provided that suitable types of microphone and loudspeaker are used, they are well-separated from each other at each end and they are used only in rooms that have suitable acoustical properties.' (Richards, D.L. 'Communication by speech - The important factors in telephony', Paper presented for the Institution of Post Office Electrical Engineers, London 1970).

(27) Cable TV distribution networks will undoubtedly move away from the simple distribution of a few channels towards both greater feedback and greater selectivity. The Rediffusion 'Dial-a-program' system which uses a narrowband feedback line from the user to select from a theoretically unlimited variety of channels is one example; a working system of this kind is being currently installed in the Cape Cod area. Although there is some disagreement over the possibility of ultimate integration of telephone and video services (A.T. & T. taking the view that the two systems must be regarded as essentially and permanently separate) there does seem to be general agreement that with feedback capacity and greater selectivity the cable TV distribution system will increasingly acquire the characteristics of a many-to-many telephone system. This type of development, and its possible practical applications, are discussed in the August 1969 report of the Committee on Telecommunications of the National Academy of Engineering (National Academy of Engineering, 'Telecommunications for enhanced metropolitan function and form', Washington August 1969), and in the October 1969 filing by the Electronic Industries Association of FCC Docket 18397, Part V.

(28) Although the degree of integration between the telephone network and the cable TV distribution network in the Post Offices pilot scheme at Washington New Town, County Durham, is extremely limited, the value of such experiments is that they point the way towards more fully integrated future systems. At present the two networks are electrically separate, the main economic benefits accruing from the sharing of common plant such as ducts, trenches, jointing boxes and cabinets. Granger argues that 'the long term objective might need to be approached in several stages, each taking advantage of new technological processes. This will probably lead to the development of a general-purpose local-line network operating on a digital basis, which could provide customers with any telecommunication services desired, including the broadcast sound and television services, telephone, viewphone and miscellaneous data and signalling services. It is conceivable that such comprehensive facilities could be delivered to each user by means of a single communication 'pipe' providing connexion ta general-purpose communication 'main'. (Granger S.H. 'Post Office Wideband Distribution Network at Washington New Town', Post Office Electrical Engineers' Journal, Vol. 61, Part 1, April 1968).

(29) It is for this reason that the Post Office is able to charge the same rate for a dialled call over a distance of 50 miles or 500 miles.

(30) This is a point for which the writer is indebted to Dr.E.T.Klemmer, of the Human Factors Department, Bell Laboratories, Holmdel, N.J. U.S.A.

(31) In a system of n stations each of which may be connected to every other pairwise, the number of potential links is n(n-1)/2. If conference calls of up to n participants are permitted, the number of potential links is very much greater, at 2 to the power of n. Under these circumstances the addition of each station doubles the number of potential linkings.

(32) Thus the number of telephone stations in the UK increased from 7.2 million in 1957 to 11.3 million in 1967. Counting only pairwise links this represents an increase from 25,920 billion potential links in 1957 to 63,845 billion in 1967.

(33) Some indication of the size of the directory assistance problem can be found in the fact that in the year 1970/71 the enquiry centres of the London Telecommunications Region handled 49.5 million enquiries. Although productivity is high (these enquiries were handled by a daytime staff of 900 female operators plus 200 night shift male operators) this is a type of activity which is labour intensive and will increase sharply in cost. Moreover the fact that an increasing proportion of traffic is in long distance and international calls, where directory assistance is more likely to be required, will also aggravate the situation.

(34) Roy, in his study of informal communication among machine operators, concludes that 'these observations seem to support the generally accepted notion that one key source of job satisfaction lies in the informal interaction shared by members of a work group' (Roy D.F., ''Banana Time' Job Satisfaction and Informal Interaction', Human Organization, Vol.18, No.4, Winter 1959-60). In a study of an academic department and two industrial research and development laboratories O'Gara demonstrated the relationship between the physical distance separating people and their probability of technical communication. He found that communication probability decreased with the square of distance, and generally reached its asymptotic level at about 25 yards. (O'Gara P.W. 'Physical location as a Determinant of Communication possibility among R&D engineers', Cambridge Mass., MIT Sloan School of Management, unpublished S.M. Thesis, 1968).

(35) There is some evidence that when a work group increases in size, and the opportunities for communication decrease, job satisfaction tends to decrease. (Indik B.P. 'Organization size and member participation: some empirical tests of alternative explanations', Human Relations, 1965, 18.). Indik's results clearly indicate that larger groups do have more difficulties of communication and less satisfaction from work. It is arguable that the two are connected. Frequency of face-to-face contact certainly appears to be an important determinant in the formation of cohesive groups. 'A basic condition for the spontaneous formation of a particular group is that the individuals involved have sufficient contact with one another to become acquainted. The probability that two people will become acquainted tends to increase with the frequency that they find themselves in physical proximity. Thus, spontaneously formed groups tend to be composed of individuals who reside near one another, work in geographical proximity, 'hang out' on the same street corner, or are thrown together by other activities in their daily lives'. (Cartwright D.

& Zander A., 'Group Dynamics: Research & Theory', Harper & Row, 1953.)

(36) Burns, in his discussion of the work of Hutte and Cohen on silent films of individuals entering offices, from which audiences had to judge the relative ranks of the individuals, says: 'We are all able to read entering a door without knocking, knocking and entering without giving time for an answer, knocking and waiting for an answer, and knocking until the answer is repeated more loudly, as indicators of different degrees of rank. What was interesting was that in the brief space of a minute there seemed to be so many clues available about the relative rank of the two people that many of those in the audiences .. tended to become confused. This was partly because an enormous amount of redundant information was communicated by the behaviour, posture, and gestures of the two men, but also because certain spontaneous 'unscripted' gestures were 'out of character' and sowed confus ion by contradicting others... Experience with this film makes one acutely aware of the existence of an elaborate and sophisticated system of human communication about social status'. (Burns T. 'Non-verbal communication', Discovery, October 1964).

(37) Any system based on shared studios suffers the considerable disadvantage that conferences need to be booked in advance at both ends. This counteracts the great potential advantage which telecommunications systems enjoy of immediate availability. Shared systems also tend to involve setting-up and preparation which discourage spontaneous use. These disadvantages must be weighed against the greater utilisation and economy which sharing allows; the balance between these advantages and disadvantages will shift continuously as the comparative costs of terminal equipment, transmission channels, and offices space, vary.

(38) Laboratory work of this kind constitutes the role of the Experimental Research Team in the Communications Studies Group, Joint Unit for Planning Research.

(39) Bell Laboratories, Holmdel, N.J., have carried out numerous studies of this kind. In one such study some 2000 participants in conference (multi-point) telephone calls were interviewed by telephone within a few hours of completing their call, and were asked their opinion about the quality of the connection. In another study long-term users of the AT&T Bell corporate Picturephone network were interviewed by Picturephone to obtain information on their use of the system, their knowledge of its ancillary facilities, and their attitude to Picturephone as an alternative to face-to-face meeting.

(40) It has been found that when an advanced telecommunication link, such as a video or audio conference communication system, is added to an existing situation, there is some difficulty in achieving spontaneous use. This has certainly been the experience of Bell Laboratories, Holmdel, with their audio and video conference links to Bell Laboratories. Murray Hill. This suggests that in a stable state communication patterns become adapted to the currently available communications systems, and that considerable inertia may need to be overcome if people are to alter their pattern of work and take full advantage of a new system. An important advantage of the laboratory/field type of experiment described here is that the removal of the individual from his work group would force him to change his habits and rely upon electronic communication systems. Any inadequacies in the electronic systems as substitutes for face-to-face contact would then become immediately apparent, and would not be masked by low utilisation rates arising from sheer inertia.

(41) This impact was particularly severe in the case of the journey to work. Data from the Association of American Railroads on trends in railroad commutation between 1922 and 1954 show that the annual number of passengers carried fell from 429m. in 1922 to 229m. in 1940. A number of companies were in severe financial difficulties at this time. But the second world war came as a massive shot in the arm for transit systems, and the number of railroad commuters carried rose each year during the war, to reach a high point of 344m. in 1947. But although only 610 new passenger vehicles were produced in the United States in 1944, over 2m. private cars were marketed in 1946, and over 6.75m. in 1950. This was reflected in the railroad commutation figures, which dropped steadily from 344m. in 1947 to 246m. in 1955. By 1956 Owen was writing that of the twelve cities in the United States with population densities in the central city exceeding 10,000 persons per square mile, most transit systems were in financial difficulties or had recently been in such financial condition that it had been necessary to resort to public ownership. These cities included New York, Chicago, Detroit, Boston, San Francisco, Pittsburgh, Milwaukee and Philadelphia. (Owen W. 'The metropolitan transportation problem', The Brookings Institution, 1956).
The impact of the automobile on rail travel for leisure purposes was even more severe. Meyer Kain & Wohl ('The urban transportation problem', Harvard University Press, 1965) quote the Executive Vice President of the American Transit Association as saying in 1961: 'At one time, weekend and holiday transit riding was often almost as good as on weekdays. However, the prevalence of the five day week, combined with the automobile and other factors, has caused Saturday riding to drop to about 61% of the average weekday level in 1959. Sunday and holiday riding last year (1960) dropped to 30% and 33% respectively of the weekday average for all cities'.
Thomas, in his review of the journey to work in London, calculates that peak travel on the London Underground increased by 14% between 1951 and 1967, whereas off-peak travel declined by 43% in the same period. He attributes the shift to increased ownership not only of cars, but also of television (keeping people at home in off-peak periods), and argues that rising fares have exacerbated the trend since off-peak demand is much more elastic than peak demand. (Thomas R. 'Journeys to work', Political and Economic Planning, London 1968).

(42) 'The inherited layout of the streets inside most towns is not suitable for the movement of motor vehicles. To develop its characteristics a motor vehicle requires a reasonably clear, uninterrrupted run, but in the close criss-cross layout of our urban streets there are intersections at very frequent intervals each of which is a potential obstruction to the flow and the scene of the notorious 'right-hand turns' which cause so much delay. Many of the streets are too narrow for the number of vehicles which use them ... The result of growing numbers of vehicles endeavouring to force their way through this narrow, intricate street system has been increasing congestion and inefficiency'. (Buchanan C.D. 'Traffic in Towns' H.M.Stationery Office, 1963).
'Erosion of cities by automobiles entails so familiar a series of events that these hardly need describing. The erosion proceeds as a kind of nibbling, small nibbles at first, but eventually hefty bites. Because of vehicular congestion, a street is widened here, another is straightened there, a wide avenue is converted to one-way flow, staggered-signal systems are installed for faster movement ...' (Jacobs J. 'Death and Life of Great American Cities', Penguin Books, London, 1961).

(43) The fare cost of travel, either by rail or air, tends to rise as an almost linear function of distance. But the major cost of business travel arises from the value of the time spent in travel; this will also rise with geographical distance between origin and destination, but the rate at which it does so is dependent on the frequency of service, and the position of the origin and destination on the transportation network. Because rail or air travel involves certain fixed time elements at each end in end-trips and waiting, the time cost is a less than linear function of distance. The cost of telecommunication also increases with distance, but in the case of calls on the public network, it does so in a series of sharp steps. These steps coincide either with arbitrarily selected boundaries of charge areas, or at international frontiers. Within the U.K. tariffs are based purely on geographical distance, and the position of origin and destination on the telecommunications network do not affect the price of the call, although they clearly affect the real cost.

(44) Hall has identified four distances for face-to-face interaction. The closest ('intimate distance', contact to 18 inches) involves, according to Hall 'greatly stepped up sensory inputs. Sight (often distorted), olfaction, heat from the other person's body, sound, smell, and feel of the breath all combine to signal unmistakable involvement with another body'. Hallssecond distance ('personal distance') extends from 18 inches to four feet. 'Subjects of personal interest and involvement can be discussed at this distance. Head size is perceived as normal and details of the other person's features are clearly visible. Also easily seen are fine details of skin, gray hair, 'sleep' in the eye, stains on teeth, spots, small wrinkles, or dirt on clothing'. Hall's third distance ('social distance') extends, in the 'close phase' from four to seven feet, and in the 'far phase' from seven to twelve feet. At these distances 'intimate visual detail in the face is not perceived, and nobody touches or expects to touch another person unless there is some special effort'. Hall argues that 'Business and social discourse conducted at the far end of social distame has a more formal character than if it occurs inside the close phase. Desks in the offices of important people are large enough to hold visitors at the far phase of social distance. Even in an office with standard-size desks, the chair opposite is eight or nine feet away from the man behind the desk'. Hall's final distance ('public distance') covers interpersonal distances above twelve feet. This is the distance employed by public figures: 'Not only the voice but everything else must be exaggerated or amplified. Much of the nonverbal part of the communication shifts to gestures and body stance. In addition, the tempo of the voice drops, words are enunciated more clearly, and there are stylistic changes as well'. (Hall E.T. 'The Hidden Dimension', The Bodley Head, London, 1966).

(45) This was the main ground on which Alexander attacked the simplistically hierarchical planning of new towns. He argues that 'In a traditional society, if we ask a man to name his best friends, and then ask each of these in turn to name their best friends, they will all name each other so that they form a closed group. A village is made of a number of separate closed groups of this kind. But today's social structure is utterly different. If we ask a man to name his friends and then ask them in turn to name their friends, they will all name different people, very likely unknown to the first person; these people would again name others, and so on outwards. There are virtually no closed groups of people in modern society. The reality of today's social structure is thick with overlap - the systems of friends and acquaintances form a semi-lattice, not a tree'. (Alexander C. 'A city is not a tree', Architectural Forum, April/May 1965).

(46) Meier, writing in 1962, laid great stress on the need for face-to-face communication as an incentive towards the clustering of offices in city centres. He argues that 'the commodities and securities markets, where communications are highly integrated and minutes or seconds may make a difference, support thousands of individuals who collate records and files with the incoming price quotations and news events, and these must be compressed into a small area. Another such complex exists in government, where the slightest hint of policy change should evoke both reaction and adjustment. An administrative agency that is not on the trunk or main branches of the grapevine soon finds itself with a shrinking budget ... The need for direct face-to-face contact offers perhaps the best explanation for the strong attraction retained by the urban center. Ad hoc organizations can be freely formed and dissolved in an environment containing tens or hundreds of thousands of alert, ambitious individuals. (Meier R.L. 'A Communications Theory of Urban Growth', M.I.T. Press, 1962). Meier did not advance any empirical evidence to support this hypothesis, but empirical evidence is slowly coming forward. Goddard points out that in a recent survey sponsored by the Location of Offices Bureau, London, of those firms which approached the Bureau for advice about decentralisation and then decided not to move, 34% of the firms mentioned personal contacts with other businesses, clients and overseas visitors as the main reason for remaining in Central London, a figure well above that for any other factor. (Goddard J.G. 'Communications and Office Location: a review of current research', Regional Studies, to be published). In the current study on the location of government departments being carried out by the Civil Service Department and the Institute for Operational Research, the need for face-to-face communication has been recognised as the most important factor in favour of central agglomeration. Thus it has been concluded that 'The major disadvantage of separating blocks of work or the major advantage of regrouping them, is probably the change in efficiency resulting from changes in communications. Yet even to define efficiency for the units with which we are concerned raises problems that are, at present, insuperable ... Until empirical evidence allows us to refine the process, we rely on the assumption that relevant effects may be sufficiently closely related to the extent of changes in existing communication links, depending upon the change in separation of the blocks of work concerned and an estimate of the links' strengths'. (Elton M.C.J. et al, 'An approach to the location of government', paper to The Institute of Management Science Conference, London 1970).

(47) In 1970 the Location of Offices Bureau estimated that the additional costs of central London location amounted to £900 per employee. This was made up as follows: Rent, £600; Rates, £150; Salary differential: £150. These calculations were based on a rent of £6 per square foot for a new office in central London, and a rent of £1 per square foot for new offices outside London, allowing 120 square feet overall per employee.
Research by Rhodes at the Department of Applied Economics, Cambridge University, indicates that detailed examination of operating costs of offices in Central London and in other areas, comparing like with like, show a 20% reduction in annual operating costs. Rhodes' particular interest is in the extent to which the move of offices to areas of low employment would act as a stimulus towards regional development. He argues that the time has come for government to devise incentives for offices to move to development areas, as has been the case for industry since the second world war. (Rhodes J., 'Office Dispersal and Regional Policy', Occasional Paper, Department of Applied Economics, University of Cambridge, 1971).

(48) Although this possibility has received a certain amount of attention, the results are of three kinds. Firstly, there are those who explain that although this is a potentially important factor, no attempt has been made to take account of it. Thus the Transportation Research Group at the University of Southampton, in their study of potential traffic and sites for an inter-city VTOL service, state 'A factor which has not been considered in this Report is the possibility of developments in the technology of telecommunications which may result in changes in the methods of conducting business affairs. An area for further work should be the study of relationships which would indicate variations in trip activity with particular reference to the advancement of technology in relevant fields'.
Secondly, there are those who identify the problem, suggest some methodologies with which it might be attacked, and call for a research programme to develop these methodologies. The 1970 study of the substitution of telecommunications for transport by the Bureau Central D'Etudes pour les Equipements D'Outre-Mer, Paris, falls into this category. The final paragraph of their conclusions runs as follows:
'Soulignons enfin avecforce qu'on ne pourra esperer batir de prospective solide dans le domaine vital des communications futures avant de disposer de fondations meilleures que celles dont on dispose actuellement. Cette base, doit etre constituee rappelons-le, au moyen d'abord d'etudes empiriques permettant de mieux connaitre les interactions actuelles et passees entre la technologie des communications et certains domaines de notre environment, au moyen ensuite d'etudes experimentales, in vitro et in vivo, permettant une etude objective des usages et des effets des media deja disponibles actuellement ou en cours de developpement'. (BCEOM, 'Etude de substitution transports telecommunications', Paris, Avril 1970).
Other statements of this kind include those by Memmott (Memmott F.W., 'The substitutability of communications for transportation', Traffic Engineering, February 1963), and Healy (Healy T.J. 'Transportation or Communications: Some Broad Considerations', IEEE Transactions on communication technology, Vol Com-16, 2.).
Thirdly there are those who attempt to quantify the effect which telecommunications may have on travel. For example the Electronic Industries Association, in the filing of FCC Docket 18397, Part V (October 1969), arrives at the interesting figures of $6 billion per annum on domestic air travel, and $6 billion per annum on highways, as the savings which could be expected if one video telephone existed for every 100 office phones, and 50% of the nation's homes were wired for a broadband communications network. According to a personal communication from the EIA, 'These numbers were consensus estimates arrived at by a number of industry leaders meeting together'. We have not been able to obtain any information about the calculations, if any, on which these estimates were based.
Another example is that of the Committee on Telecommunications of the National Academy of Engineering. Their August 1969 report concludes that 18% of present urban-area vehicle-miles traveled might be avoidable with increasing use and sophistication of telecommunications facilities. However this figure is extremely dubious, since it is based on indices of 'susceptibility of work-related trips to substitution' for different types of employees, and these indices do not appear to be based on any theoretical or empirical foundation. The projections also make the assumption that the proportion of white-collar workers to the whole work force will not change significantly. Nonwork-related trips are treated in a similar fashion, indices being assumed for substitutability for different trip purposes (e.g. 50% shopping, 25% educational, civic, and religious, etc.). (National Academy of Engineering, Committee on Telecommunications, 'Telecommunications for Enhanced Metropolitan Function and Form', Washington 1969).

(49) This assumption lies behind the interest of transportation engineers such as Memmott in the potential of telecommunications substitution as a means of reducing road congestion. He argues that 'There is a strong probability that this substitution phenomenon will be forced upon us whether we desire it or not. Increasing traffic congestion will reduce person trip generation rates by eliminating unnecessary trips and will accelerate the gradual substitution of communications for transportation'.

(50) Although the UK telephone system comprises only about one twentieth of the world's telephones, over 99.5% of all calls handled by the UK system in 1969/70 were internal to the UK. Thus out of 9,635 million calls, only 32.5 million were international. The number of local calls likewise exceeds considerably the number of long-distance domestic calls, the figures for 1969/70 being as follows: local calls: 8,270 million, long distance calls: 1,333 million. If distance had no effect one would expect the calls to be fairly evenly distributed throughout the system.

(51) Human geographers interested in the general question of the diffusion of innovations have given considerable attention to the way in which an individual's knowledge of his environment decays with distance. Thus Pred says that 'In general the quantity and quality of relevant private information in possession of the locational decision-maker is affected by his geographic, or site and situation, characteristics since interpersonal exchanges of information are inclined to be most intense at very short distances. In other words, because of daily time-budget constraints, on the average, the density of contacts included in a single person's private-information field must decrease very rapidly with increasing distance'. This quotation from Pred (Pred A., 'Behaviour and Location', Lund Studies in Geography, Ser.B, No.27, 1967), like the work of Hagerstrand on which it is partly based (Hagerstrand T. 'Innovation diffusion as a spatial process', University of Chicago Press, 1967), emphasises the importance of face-to-face contact as a means of acquiring information about the environment. It is recognised that these patterns of face-to-face contact may spread in a hierarchical fashion from the large urban centres, to regional centres etc., rather than simply by even diffusion across space, and the use of telecommunications systems would clearly favour this hierarchical type of spread.
The study of the spatial diffusion of innovations has been closely tied up with the study of population migration, since population migration is an important method of innovation diffusion (Brown L.A. 'Diffusion Processes and Location', Regional Science Research Institute, Philadelphia, 1968). Conversely the level of information which an individual possesses about potential destinations is a crucial factor in migration decisions. The individual's level of information about potential contacts is likely to be an equally crucial factor in his decision to communicate.

(52) 'It is certainly true to say that, on historical time scale, there can be immense economic and other social advantages in using a new technology for increasing centralisation. This was as true of railways as of telephones or broadcasting. The institutions of government, of law, of education and those of other overall social need can then grow in size and effectiveness. We see this today happening at international level: the reliable trans-Atlantic telephone (introduced in 1956 by cable and satellite) has enabled new great 'international corporations' to develop whilst, in combination with high-speed aircraft, telex, duplicating machines and other technologies, many practical constraints have been removed upon the operation of the global international organisations, now some 2500 in number' (Cherry C. 'Electronic Communication: a force for dispersal', Official Architecture and Planning, Sept. 1970).

But this type of centralisation of control need not be accompanied by geographical centralisation. Although geographical centralisation and geographical decentralisation are mutually exclusive opposite choices, centralisation of control (which Cherry is discussing here) is quite compatible with geographical decentralisation. Whistler, in his study of the effect of the introduction of advanced information technology on organisational structure, uses three measures of centralisation, none of which is geographical. They are: 1. Direct influence of each individual on organisational tasks, measured by compensation paid to each individual. 2. Perceived reciprocal influence exerted by individuals upon one another, measured by individual perception questionnaires. 3. Formal influence as superiors and subordinates, measured by span of control. He concludes that the effect of improvements to information technology is to centralise control, although he argues that this may be a transitional effect until power is re-distributed through reorganisation. (Whistler T.L. 'The Impact of Information Technology on Organisational Control', in Myers C.A. (ed) 'The impact of computers on management', M.I.T. Press 1967.).

(53) Bernal points out that although the major demand for printed material in the fifteenth century was for religious and literary works, in the sixteenth century it became the medium for scientific and technical change. 'Hitherto the techniques of the craftsmen had been traditional and never written down. They were passed on from master to apprentice by direct experience. Printed books made it first possible and then necessary for craftsmen to be literate' (Bernal J.D., 'Science in History', Vol.1., Watts, London, 1954).
But the introduction of writing and printing clearly had effects at an even more fundamental level. Gough argues that: 'Literacy appears to be, above all, an enabling factor, permitting large-scale organization, the critical accumulation, storage and retrieval of knowledge, the systematic use of logic, the pursuit of science and the elaboration of the arts. If (these developments) occur, there seems little doubt of Goody and Watt's contention that the use of writing as a dominant communications medium will impose certain broad forms on their emergence, of which syllogistic reasoning and linear codifications of reality may be examples'. (Gough K., in Goody J. 'Literacy in Traditional Societies', Cambridge University Press, 1968).

(54) The main core storage of the largest computer in the IBM 360 range has a capacity of 1 megabyte. Since each byte is equivalent to nine bits of information (including parity) over 9 million individual ferrite cores are required. Each of these individual cores is capable of only the simplest operation, namely adopting one of two states. The largest computer in the IBM 370 range has a main core capacity of 3 megabytes.

(55) 'It is impossible to judge what will happen to the species Homo sapiens during the next 500,000 years, but during the last 10,000 years no considerable changes have taken place in man's biological organization. In particular, the size of his brain not only has not increased, but it has actually decreased slightly. The process of evolution of the brain in modern man has evidently not followed the lines of a quantitative increase in the size of the nerve cells, the number of which is extremely large, but along the lines of an increase in the complexity of the connections between the elements. It is in this way that the development of human faculties and adaptations to the most varied conditions of existence have taken place' (Blinkov S.M. & Glezer I.I., 'The Human Brain in Figures and Tables', Basic Books Inc., 1968).
Estimates of the total number of cells in the human cerebral cortex (both hemispheres) range from 10 to 18 billion.

PART 2: AREAS OF RELEVANT RESEARCH

It was argued in part I of this paper that policy for the future development of person-person telecommunications should be based on a thorough understanding of telecommunications needs, telecommunications technology, telecommunications effectiveness, and telecommunications impact. In fact the necessary understanding exists in only one of these areas, namely that of technology. This is the result of the combined, and formidable, efforts of the military and industrial research organisations, and the well established academic disciplines of electrical and electronic engineering.

Yet although the study of human interaction occupies a central place in a number of disciplines, the human aspects of person-person telecommunications have been curiously ignored. The well-organized platoons of the established disciplines have marched around, rather than across, this area of research. Its interior is occupied only by a few skirmishing parties and stragglers from the major academic disciplines. My purpose in what follows is to demonstrate this general neglect, and describe some of the few directly relevant areas of research.

Information theory

Because the concepts of mathematical information theory are applicable to language, they might be thought to be applicable in general to the process of interpersonal communication. But there are two reasons why this is not so. Firstly, the use of the mathematical theory of communication requires clear definition and measurement of the signals that are to be transmitted. Electrical signals, and the verbal utterances to which they exactly correspond, may be broken down and analysed in this way by means of Fourier analysis (56). Written language may be analysed as a defined sequence of characters from a limited vocabulary. And man-machine interaction, insofar as it consists of a limited number of definable sensory inputs and controls, is likewise amenable to mathematical analysis. But the process of face-to-face interaction, involving participants in communication by means of sight, sound, touch, and smell, not only with other participants, but also with the architectural or natural environment in which the meeting takes place, defies precise measurement or analysis. And to this extent the mathematical theory of communication is an inappropriate tool for its study.

But even if the numerous channels employed in face-to-face communication could be measured, there is a second reason why information theory

would be unlikely to contribute to an understanding of the purposes and effectiveness of the communication process. Arising, as it did, from the desire to make the most economical use of telegraph and telephone circuits (57), such theory represents a powerful approach to the efficient coding of language. But as Cherry points out, 'The formal mathematical theory is of direct application only to the technical equipment itself, from microphone to headphones or loudspeaker, and is abstracted from the specific users of the equipment ... Engineers are concerned primarily with the correct transmission of signals, or electric representations of messages; they are not commonly interested, professionally, with the purposes of messages - whether they be trivial gossip, serious news, or racing tips' (58).

If the problem of communication is divided, in Weaver's terms (59), into the technical problem (of signals and their correct transmission), the semantic problem, and the effectiveness problem (the effect of signals upon the behaviour of the recipient), information theory is clearly applicable only to the first of these three areas. It throws little light on the needs for, or the effectiveness and impact of, future telecommunications systems (60).

The crucial role of information theory is the technological one, of ensuring the most economical and faithful transmission of electrical signals. Indeed as the demand for complex data and video services grows, the problems of providing integrated and economical methods of encoding information will be of increasing importance (61).

Applied psychology

Applied psychology in telecommunications, as carried out by or for the human factors departments of telephone administrations, falls into two main categories; on the one hand telephone equipment studies, and on the other transmission performance studies. Customer telephone equipment studies tend to be more concerned with the process of setting up calls than with the actual telephone conversation. This is because numerous variations are possible in the mechanisms and procedures by which calls are set up, and each of these variations must be evaluated experimentally. Such experiments, which typically take place under realistic conditions in a laboratory, may be concerned with the size, design, and weight of the telephone handset, the configuration of the dial or push-buttons, or the number and characteristics of signalling tones (62). Alternative designs in each of these areas may affect the speed of setting up calls,

dialling error rates, and customer satisfaction. The first two of these are just as important as the last, since slow dialling and re-dialling ties up scarce exchange switching equipment which is released once the call is established. In view of the large total volume of telephone traffic, it can be appreciated that even marginal changes in individual call performance may have an important cumulative effect on the operation of the telephone system (63).

Although these studies are clearly of continuing importance, they are really concerned with the individual as an operator of the telephone system, setting up and receiving calls. They are not concerned with the individual as a communicator, attempting to achieve communication goals. They have much in common with the large body of applied psychology, much of it of military inspiration, on the optimal design of displays and controls. They tend to be concerned with perceptual processes, memory, response, and vigilance, rather than with social psychology (64). As a result of the advent of visual telecommunications systems, some similar work is now being carried out on optimal methods for the display of television pictures and alpha-numeric data. But again, such studies tend to concentrate on the admittedly important details of format and configuration, rather than on the broad utility of such systems as tools of human communication.

In turning to transmission performance studies, the picture is likewise one of a meticulous, but limited, approach. These studies are primarily concerned with the subjective effects of loss, noise, and attenuation and delay distortion in telephone connections. They typically involve small group laboratory experiments, in which pairs of subjects are asked to converse across a telephone link whose characteristics may be varied to simulate the particular impairment under investigation (65). Although there has been a continual improvement in the quality of connections offered to the public, the recent thrust of this type of work has been in the direction of assessing the subjective effect of impairments rather than improvements. This is because recent technological developments, including pulse code modulation, communication satellites, and digitally switched electronic exchanges, have resulted in new types of distortion and longer propagation times (66). Human factors research on telephone transmission has therefore found itself to be working in a range of quality whose upper bound is the conventional 'excellent' or 'good' telephone connection, and whose lower bound is the 'fair' or 'poor' one. For it is between these bounds that, in terms of subjective

assessment, the new types of circuit lie. In any case it is regarded as unnecessary to provide anything better than the conventional 'excellent' connection, and commercially unacceptable to provide anything worse than 'fair' to 'poor' ones. Although the resulting range represents a narrow slice of the total spectrum of telecommunications systems, it is a matter of great practical importance to be able to measure accurately within it. Because of the size of the telephone system, and because a marginal improvement may require wholesale alteration of telecommunications equipment, small variations in subjective quality may be associated with substantial cost differences (67). Moreover the increasing importance of international calls requires detailed compatability in transmission standards.

Although these impairments may be described accurately in electrical terms, the problem of measuring their effect upon the telephone user is extremely difficult. If subjects are asked to undertake realistic and measurable communication tasks via different telephone systems within this range, no differences in their objective performance are observable (68). For this reason earlier methods, such as articulation tests, which yielded objective performance measures, have had to be abandoned in favour of purely subjective rating scale type of assessment. Unfortunately these rating techniques do not lend themselves to the evaluation of novel systems, since they would appear to rely on the subject assessing the system under investigation in terms of his previous experience of telephone calls. Work by the Post Office on the subjective assessment of picture quality in video-telephones, involving subjects viewing still pictures shown on television displays of the appropriate size, presumably results in subjects assessing the pictures in terms of their previous experience of broadcast television (69). There is no evidence to suppose that this criterion bears much relationship to the desirable qualities of a video-telephone. Just as it was not feasible to apply the earlier articulation tests to better quality telephone connections, it is unwise to transfer the methods recently developed for the subjective assessment of transmission impairments to the general problem of evaluating novel communications systems.

Thus the current research on both customer telephone equipment and transmission performance, described above, has little applicability to the general question raised in this paper.

But there are signs that the necessity to broaden the scope of human factors research is beginning to be appreciated. At Bell Laboratories, Holmdel, N.J., an interpersonal communications group under

Dr.E.T.Klemmer, is engaged in a programme of field surveys of communication activity, coupled with laboratory evaluation of alternative communications systems under controlled conditions. The first field survey, carried out in 1969, investigated the communication habits of Bell Laboratories personnel at Murray Hill and Holmdel. Spot check observations were made of the activities of 3132 employees, in their offices or workshops. These were compared with the results of a questionnaire survey in which 2626 employees were asked to estimate how they divided their time between their various activities. It was found that employees spent around a third of their time in face-to-face communication or on the telephone, and around another third on reading or writing (70). These findings emphasise the important role of communication in research and development laboratories (71), but do not yield any specific information about the nature of the communication in question, and whether it could have been carried out by another medium.

A second field survey, carried out in 1970, was concerned with travel by Bell Laboratories personnel between 15 different company locations. Several interesting findings arose out of the analyses. They included who the travellerswere, why they travelled, for how long and how much, how trips could best be characterised, and what types and combinations of telecommunication facilities would, in the view of the travellers, have acted as adequate substitutes (72).

Dr.Klemmer's group has also begun some laboratory experiments similar to those being undertaken at the Joint Unit for Planning Research, in which subjects' performance in carrying out realistic controlled communication tasks via different media is compared. Other experiments, more in the nature of field trials, have employed one medium only, such as Picturephone, or closed circuit conference television, or audio conference systems, for real meetings. Participants' comments and criticisms are elicited by means of post-use questionnaires. Some generally similar work is also under way at Bell Canada Northern Electric Research, Ottawa, Canada (73).

Experimental social psychology

Communication is central to experimental social psychology research, particularly to that substantial part of the field which deals with dyads and small groups. Whether the process under study is person perception, attitude change, problem solving, bargaining, or the emergence of group structure, it is a process which occurs by means of communication.

No attempt will be made here to review the variety of theories and the substantial body of experimental evidence which have been accumulated in the course of such work (74). It is however worth making the positive point that this research forms a valuable background to the design of improved telecommunications systems, concerned as it is with the very processes of interaction for which telecommunications systems ought to be designed. And it is necessary to make the negative point that in all this huge body of experimental social psychology research, the question of communication by any media other than face-to-face has been virtually ignored. Thus the extensive bibliography of small group research by McGrath and Altman (75) lists 2699 items, many of which are based on experimental studies. Yet of these only a handful are concerned with groups who communicate other than face-to-face, and none are concerned with the telephone. The research which is perhaps of the most immediate relevance to telecommunications design is that which is concerned with the way in which the different channels of face-to-face communication are used. Yet the relevance of this work arises more from accident than design. Thus Argyle, in his book 'Social Interaction' (76), much of which is concerned with communication channels, cites about 1000 references, none of which have anything directly to do with communication by telephone. For despite their obvious relevance to each other the fields of social psychology and telecommunications engineering have made little contact. Cherry, in the 1966 edition of his book 'On Human Communication', cites over 400 references, yet only two of these also appear among the 1000 to which Argyle refers, despite the fact that both books are for the general reader, and both are directly concerned with human communication (77). There seems every opportunity for a fruitful transfer of both theory and experimental method from social psychology to telecommunications engineering, a transfer that will be particularly valuable as the telecommunications system moves away from simple one-to-one voice communication towards more sophisticated visual and multi-person systems.

In this context two particularly relevant areas of social psychology research are those which examine the role of visual signals in interaction, and those which are concerned with the pattern of the communication network.

The visual signals which play a part in social interaction range from, at the smallest scale, minute movements of the eye arising from changes in gaze direction, up through facial expression, head position, gesture, posture and dress, to at a larger scale, the way in which

individuals move around a room or choose their seating position. Each of these types of visual signal has been studied both under controlled laboratory conditions and in the field.

For example Exline, Argyle, and Kendon have all studied the way in which gaze behaviour is related to other parameters such as the pattern of utterances in conversation, the personality, sex, and role of the participants, or the physical distance between them (78). Other research, such as that by Schlien, Birdwhistell, and Ekman, has been concerned with the role of facial expression, gesture, and posture, in interaction (79). At the larger scale questions of how and why people adopt certain patterns of speaking distance and standing or seating position, have been examined by, among others, Mehrabian, Hall and Goffman (80).

There is ample evidence from this work that non-verbal cues, only some of which are under conscious control, perform a number of functions in face-to-face interaction. These functions appear to include the amplification, extension (and sometimes contradiction) of the verbal message; the provision of feedback to the speaker from his audience; and the smooth apportionment of speaking time among a group. But there is littleevidence of how important these functions are in terms of their contribution to effective communication. This is because there has been little systematic research which compares the process of communication via different media. We have located only a few such experiments, and their results are inconclusive (81).

Whereas the work on non-verbal communication has important implications for the effectiveness of telecommunications channels, the studies of communications networks in small groups have some implications for telecommunications systems. In a group of N persons there are potentially N(N-1)/2 links connecting them. The effect of removing some of these links has been the subject of a number of laboratory studies. At one extreme the difference in problem solving task performance between full communication conditions and zero communication conditions has be investigated (82). And Bavelas, in 1948, was one of the first to open certain paths of communication between members of a group, while closing others. This involved an apparatus in which subjects could pass notes to each other via designated routes, these routes corresponding to 'wheel', 'Y', 'chain' or 'circle' patterns. It has been found that both group performance, and the motivation of individual members, are significantly affected by the shape of the communication pattern, and the individual's position in the network (83).

Management studies

Among those who study organisations, the central importance of communications is well recognized. Thus Katz & Kahn (84) ... devoting a chapter to 'Communication: the flow of information' write: 'The closer one gets to the organizational center of control and decision-making, the more pronounced is the emphasis on information exchange. In this sense, communication - the exchange of information and the transmission of meaning - is the very essence of a social system or an organization'. And Deutsch, in 'On Communication Models in the Social Sciences' writes: 'Communication and control are the decisive processes in organizations. Communication is what makes organizations cohere; control is what regulates their behaviour. If we can map the pathways by which information is communicated between different parts of an organization and by which it is applied to the behaviour of the organization in relation to the outside world, we will have gone far toward understanding that organization' (85).

But writers on organisations, who pontificate a good deal about communication, do so untrammelled by any significant amount of facts about the actual communications which occur within organisations. In fact the writing on the subject has much of the air of the work on transportation which preceded the advent of quantitative studies of traffic patterns. Thus organisational communication tends to be broadly categorised as 'upward', 'downward', 'horizontal', or perhaps 'diagonal'. But as Katz & Kahn point out: 'There are no studies of the distinctive types of communication which characteristically flow horizontally, upward, or downward in organizations, although such research is much needed' (86).

Given the acknowledged importance of communication within organisations, the number of studies which attempt to quantify the amount of time spent in communicating, let alone the nature of communication which occurs, are comparatively few.

Studies of the amount of time spent in communicating appear to have concentrated on managers and research scientists, perhaps because communication is such an essential activity in each case (87). A 1958 study by the Operations Research Group of Case Institute of Technology involved 1500 industrial chemists in 42 different companies. A total of about 25,000 observations were recorded; they indicated that the chemists spent about half of their day in business communication and about a quarter of their time working with equipment (88). Other studies on technical personnel include those by Hinrichs of 232 chemists and chemical engineers (89), and a recent study by Snyder and Klemmer

at Bell Laboratories, referred to above. Stewart, in her diary survey of 160 managers, found that talking or discussion was the largest single activity, occupying half the average manager's time (90).

There are a few studies which go beyond the general question of the amount of time spent in communicating to investigate the actual nature of the communication which occurs. Palmer & Beishon recorded all communication by the personnel manager of a medium sized printing firm over fourteen working days (91). The manager wore a halter microphone and pocket transmitter, the signals being picked up and recorded on a portable tape recorder carried by the observer, who also recorded a commentary on the second track of the tape. Apart from yielding information on the amount and type of the manager's communication, analysis of these tapes shows the intricate sequences of both topic and medium in which these communications occur (92). The weakness of the results is of course that they apply only to a sample of one.

The problem of tracking the communications patterns of larger groups has usually been tackled by a combination of diary and questionnaire methods. Using the self-recording contact diary technique, Burns, in 1954 studied the internal communication patterns of 4 members of a departmental executive group in an engineering factory over a period of 25 working days (93). The same method was used by Weinshall, in his 1959 study of 34 members of the management of the Devon Corporation, over a period of two weeks (94). Hesseling was responsible for a number of similar studies at European branches of Philips N.V., using combinations of diary self-recording, questionnaire, and gaming (95). An associated 1968 study by Graves, whose specific purpose was to compare the management structures of French and English factories, involved the use of self-recording contact diaries by 58 employees over a period of 11 working days (96). Conrath & Johnson, of Bell Canada Northern Electric Research, used contact diaries in their 1970 study of all 'essential' communications by 350 managers and senior staff of a manufacturing and sales division over a five day period (97).

In general these studies concentrate on internal communication among the sample, and in general the data is analysed at two broad levels. Firstly, the individual contacts may be classified as to their type, purpose, and duration. Because these studies are largely internal, and can thus pick up both 'ends' of a contact, the differential perceptions of the contact by each participant may be usefully compared. Secondly the overall pattern of communication between the members of the sample

may be analysed as a structure, and compared with other structures, such as the formal organization chart. Although confined to the business environment, these studies are clearly of the utmost importance. They provide the baseline from which the needs for, and the impact of, better methods of organisational communication may be predicted. But having been carried out by different researchers, at different times, and in different places, their contact diaries, and hence their data, unfortunately conforms to no standard pattern. The value of future studies would be considerably enhanced if they could adopt some standardised framework of survey design. In this way it should be possible to accumulate a useful body of comparable data.

Sociology

The sociology of electronic communications amounts, in terms of published work, to the sociology of mass communication. This paper is concerned only with two-way, person-person telecommunication, and as such excludes the mass media of radio and television. At present the distinction between these two fields is fairly sharp. Thus interpersonal telecommunication is almost exclusively a matter of one-to-one, two-way, voice only communication, whereas the broadcast systems involve one-to-many, one-way, voice and video communication. But these distinctions are likely to blur as the telephone system moves towards video and conferencing capability, and as the broadcast systems acquire, by means of cable TV, some of the selectivity and feedback characteristics of the telephone system. For this reason it is worth touching briefly on the main lines which research in mass communications has followed.

The first point to make is that the amount of research in this field is enormous. Hansen & Parsons, in the 1968 bibliography, included 3,000 items published between 1945 and 1967, and rejected another 7,000 published during the same period (98). Laswell has suggested that a convenient way to describe an act of communication is to answer the following questions: Who? says What? in which Channel? to Whom? with what Effect? He goes on to describe the five fields of study with which these five questions deal as: Control Analysis, Content Analysis, Media Analysis, Audience Analysis, and Effect Analysis (99). These are the categories followed here.

The mass media, unlike the one-to-one interpersonal media, put great power in the hands of a few communicators. The question of control therefore becomes an important one, and has received a good deal of attention. At one level there are questions of the relative roles of the

individuals who contribute to the production of a newspaper or television programme (100). At a higher level there are the general questions of the overall financial and political control of the media. A recent and lively interest here is in the possibility of gearing the use of television to local community needs, rather than to industrial and commercial objectives (101).

The content analysis of mass communication is now a well-established technique, which has been applied to newspapers, radio, television, and film. Berelson has described content analysis as 'a research technique for the objective, systematic and quantitative description of the manifest content of communication' (102). It typically involves counting the number of words or square inches given over to particular topics, and the frequency with which certain references or symbols appear. Numerous inferences and analyses may then be made from this data. Barcus' somewhat incestuous content analysis of 1,000 content analysis studies which had been published between 1900 and 1958 (including 500 masters' theses) gives some idea of the extent of this work (103).

Media analysis has been virtually confined to the comparative study of newspapers, radio, film and television Where the process of one-to-one communication has received attention, it has generally been in the context of the individual's role as an intermediary in the hypothesised 'two-step' flow of mass communication. The emphasis here has been on the question of who influences whom, opinion leaders being identified by means of 'sociograms' (105), and on investigating the trustworthiness and expertness of the communicator, rather than on the interpersonal medium (face-to-face, letter, or telephone) through which the communication occurs (106).

The study of the size and nature of the audience for various mass media is clearly of immediate interest to communication organisations, particularly insofar as they require to sell advertising space. These surveys are generally based on sample interviews, or in some cases on automatic monitoring devices attached to television sets (107). This type of audience research, like the content analysis referred to above, is greatly facilitated by the public nature of mass communication. To record and analyse the content of telephone calls or private letters, or to attach automatic monitoring devices to telephones, would meet considerable resistance on grounds of invasion of privacy.

Finally there is the question of the effects of mass media on their audience. Most of the work in this area has been concerned with the

portrayal of violence, or with the effect of mass communication on voting or purchasing behaviour. A number of laboratory experiments have studied the effects of viewing filmed portrayals of violence. Weiss, in reviewing these experiments, concludes that 'At best, most of the research suggests that, under certain circumstances, observation of filmed violence may lead to what the researchers call aggressive behaviour' (108). He then goes on to enumerate the reasons why it is difficult or impossible to infer anything from these findings about the actual effects of broadcast material. The reasons include the tendency for the testing situation to give the impression that aggression is permissible if not encouraged; the unrepresentative nature of the population from which the subjects are drawn (usuallypre-school children or university students); the possibility that what was interpreted by the researchers as aggressive behaviour may not in fact have been motivated by any such intent; and finally the general problem that the context and circumstances of the laboratory experiment differ from those in which the media are normally viewed. A particular aspect of this last difficulty is that of cumulative effects (109).

The studies of the effects of media on voting and purchasing behaviour have generally been based in the field rather than the laboratory. A major difficulty of such studies is that the researcher has no control over who views the material; as Weiss puts it 'Exposure is voluntary, and hence, is a matter of individual choice. This means that not only the initial contact with a communication derives from the initiative of the audience, but also continuation of exposure and re-exposure to the same or similar materials'. If therefore correlations are found between attitude and viewing, they cannot be attributed to any simple process of cause (viewing) and effect (attitude). Some statistical methods of attempting to overcome this difficulty have been described by Emmett (110), but they are generally applicable to the study of the effects of single broadcasts, or a short series of broadcasts, rather than the general cumulative effects of the mass media.

Thus the study of mass communications, concerned as it is with the control, content, audience, media, and effect, of one-to-many one-way communication, touches at many points but never directly attacks the problems of two-way person-person telecommunications.

Urban & regional planning

Practising physical planners appear to have negligible interest in communication patterns or communications technology. This is despite the growing chorus of urban commentators who insist that communications technology, like transportation technology, is an integral part of the system of workplaces, residences, and urban patterns. For example the Greater London Development Plan, a long range study intended to cover the period up to 1990, carries no reference in its extensive index to telephone, telecommunication, or electronic communication (111). By ignoring communications, urban and regional planners leave themselves unprepared to cope with whatever unwanted effects may arise from telecommunications innovation, while throwing away the opportunity to turn the new technology to advantage in achieving planning goals. Yet telecommunications technology is potentially most attractive as a planning tool. With an increasing proportion of employment oriented towards the exchange of information rather than materials, differentials in communication costs or communication capability could be expected to have an important effect on the location of employment. Investment in telecommunications, unlike large-scale road building or redevelopment programmes, has negligible adverse effect on the environment. And above all telecommunications systems are flexible, both in their day-to-day operation, and in the long term. Unlike a transportation system, where every vehicle will strive to reach its destination by the shortest route, telecommunications messages may be routed through the system via a number of paths, the overall distance travelled being irrelevant. And in the long term, additional capacity may be added to or removed from the system without any of the upheaval attendant upon large road building or redevelopment schemes (112).

Against this almost total neglect of the possible contribution of telecommunications to urban planning the activities of the National Academy of Engineering Committee on Telecommunications, and the Connecticut Research Commission must be mentioned. It is the purpose of the NAE Committee on Telecommunications to suggest ways in which urban problems may be alleviated by the application of telecommunications technology. Their main emphasis is on the solution of immediate problems, and a number of pilot studies have been proposed in the fields of education, law enforcement, medical care, transportation management, and pollution control (113). And a sub-panel of this committee is working with the Connecticut Research Commission in a study of the

application of telecommunications technology to the achievement of long-range land use goals (114).

Geography

Human geographers, concerned as they are with location within and interaction across space, have inevitably taken at least a limited interest in human communication.

One area of their interest is that of the diffusion of information across space. The work of Hagerstrand, first published in 1952, has led to an increasing interest in the spread of both innovations and migrants across space (115). Brown lists some 480 references in his 1968 bibliography on 'Diffusion Processes and Innovation' (116). Much of the work had its origins in rural sociology, spreading later to the study of industrial, educational, and professional innovations (117). There is now a considerable overlap between the work on migration and the work on information spread, since the one is seen to depend to some extent upon the other, and vice versa. The complementary roles of both mass media and interpersonal communication in the geographical spread of innovations is recognised, but the interpersonal communication process is considered as occurring face-to-face rather than by any means of remote communication. Certainly the diffusion literature has nothing to say about needs for, or the effectiveness and impact of, person-person telecommunications.

Where telephone traffic has been studied by geographers it has usually been done as a means of delimiting homogeneous areas. For example in 1936 Kawaguchi published a 'Statistical Study of Telegrams, Telephones, and Money Orders as Factors Determining the Sphere of Influence of Cities' (118). In 1953 Green used point-to-point telephone call data as a means of determining 'community of interest' hinterlands (119). Gottman, in 1961, plotted the telephone traffic generated by the cities of the eastern seaboard of the United States as an indicator of the existence of 'Megalopolis' (120), and in 1962 Ajo carried out a gravity model based study of telephone call traffic linkages in Finland (121). In all of these studies figures of telephone traffic appear to have been used as a convenient indicator of interaction, rather than out of any interest in the process of communication as such. No attempt is made, or can be made from this type of crude data, to analyse the needs for, or the effectiveness and impact of, telecommunications systems.

Fortunately there is a small but growing body of work which does

set out to analyse geographical communication flows in detail. It is being undertaken by Thorngren, of the Stockholm School of Economics, and Goddard, of the London School of Economics. In each case surveys are conducted among a population sample by means of self-recording contact diaries, similar to those used in the surveys of firms' internal communication patterns described above. Both authors are primarily interested in the question of office location, and for this reason their surveys are confined to organisational, rather than domestic, communication. Thorngren's major study surveyed 3,000 executives in 100 Swedish firms for a three-day period. Some 15,000 contacts were recorded (122). Goddard's recent survey of the communication patterns of firms in Central London involved 705 employees in 72 firms; 1544 meetings and 5,266 telephone calls were recorded (123). Much of the current effort by Thorngren and Goddard has gone into the classification of these contacts according to Latent Profile Analysis (124). Thorngren finds that three clear groupings emerge from this analysis. Firstly, there are the 'programme' contacts, typically short, occurring by telephone, involving a single topic, and comprising some 70% of all contacts. Secondly, there are the 'planning' contacts; these involve information of greater scope, with information exchanged in both directions, and last about 30 minutes, but seldom longer. Telephone and face-to-face contacts are mixed in this group. Thirdly, there are a small group of 'orientation' contacts; they comprised less than 5% of the firm's total contacts, but 80% of all new contacts. Such contacts often involve more than three participants, may last for several hours, are invariably carried out face-to-face, and are generally planned well in advance. Goddard finds his data to be in remarkably close agreement with Thorngren's. He has additionally carried out a Latent Profile Analysis on the face-to-face meetings alone, and finds that they fall into two distinct sub-groups: the first sub-group is characterised by long meetings, arranged a long time in advance but taking place infrequently, many participants, and a wide range of subject matter. The second sub-group involves meetings which are shorter, more frequent, with fewer participants, and frequently entailing the one-way transmission of orders or instructions on one specific subject (125). Goddard is now embarked upon a similar survey of firms outside Central London to investigate the effect of location on communication patterns.

Although at an early stage, these contact diary surveys of the geographical patterns of communication offer a most promising way of introducing some quantitative data into an area that has been hitherto dominated by ignorance and speculation.

Notes to Part 2.

(56) Fourier Analysis rests on the principle that complex variations of a quantity, such as the voltage in a telephone circuit, may be accurately represented as the sum of a number of sinusoidal variations of different amplitudes, phases, and frequencies. Fourier Analysis presents a powerful method for the investigation of signal wave forms; its major drawback is that simple continuous sine wave represents a perfectly sustained note, whereas the characteristics of speech signals alter continuously. The limitations of simple Fourier Analysis for describing speech signals are discussed in Cherry C. 'On Human Communication', M.I.T. Press, 1957.

(57) An early example of the application of information theory to the economical transmission of signals is that of the Morse Code. The shortest codes were assigned to the most frequently occurring letters in Morse's 1838 code. Thus the letter E is represented by a single dot. The frequency of occurrence of the letters was apparently gauged from the relative proportions of letters in a current printer's fount. This method was in fact remarkably efficient, and the application of the most modern theory would reportedly gain only about 15% in speed. (Pierce J.R. 'Symbols, Signals and Noise', Hutchinson, 1962).

(58) (Cherry C. 'On Human Communication', M.I.T. Press, 1957.

(59) (Shannon C.E. & Weaver W., 'The Mathematical Theory of Communication', University of Illinois Press, Urbana, 1949).

(60) Cherry writes of 'pragmatic information' that 'At present, no mathematical theory has been published, corresponding in any way to extensions of the existing theories. It is at this level that the true process of human communication can be considered - the use of signs by people in specific circumstances and environments, the whole 'effectiveness' problem of Weaver. To the pragmatic level we must relegate all questions of value or usefulness of messages, all questions of sign recognition and interpretation, and all other aspects which we would regard as psychological in nature' ('On Human Communication', M.I.T.Press, 1957).

(61) A number of methods of 'bandwidth compression' are under investigation with particular reference to the video-telephone. Simple methods transmit a limited number of grey levels. Among the most sophisticated methods are those which 'trade spatial and temporal resolution'. This relies on the fact that the human eye is considerably less sensitive to detail in moving images than in static ones. Those parts of the image that are not moving are therefore transmitted in the form of comparatively infrequent, high-definition pictures. Those parts of the image that are in motion are transmitted in the form of more frequent, but low-definition pictures. Systems of this kind are being studied at Bell Laboratories, Holmdel, N.J.

(62) The following titles in this area are drawn from the papers read at the 5th International Symposium on Human Factors in Telecommunications, London, September 1970: 'Customer behaviour in using pushbutton dialling telephones for abbreviated dialling and calculation services'; 'Characteristics of a keyset cancel button'; 'Human reaction to push-button sets with respect to geometry and pressure characteristics'; 'Future coin telephones - proposals based on human factors engineering'; 'Customer behaviour in dialling, some statistical aspects related to errors and ineffective calls'.

(63) 140,955 million telephone calls were made in the United States during 1968. The corresponding figure for the United Kingdom is 8,694 million. If each of the American calls had taken one second longer, this would have totalled 4469 years of extra time.

(64) This type of work is well exemplified by the research at the Medical Research Council's Applied Psychology Unit, University of Cambridge, some of which has been sponsored by the Post Office. Brown, in reviewing the relevant work of the Unit at the 5th International Symposium on Human Factors in Telephony, took as his sub-titles: sensory input, perceptual processes, memory, response, arousal and performance, and interaction of stresses. The Post Office has never, to our knowledge, funded any social psychology research. The work of the Applied Psychology Unit is described in Brown I.D., Batts V. & McGougan C.E. 'The Medical Research Council Applied Psychology Unit', Applied Ergonomics, 1, 169-176, 1970.

(65) A method of stimulating conversations currently being employed at the Post Office Research Station, Dollis Hill, consists in presenting two slightly differing pictures (of for example a landscape) to the two participants. They are then asked to identify the discrepancies between the two pictures by means of discussion.

(66) Although the introduction of high-velocity transmission systems lessened the importance of studying the effects of long-propagation times (even from the U.K. to New Zealand by submarine cable and terrestrial plant the mean one-way propagation time is only about 140ms) the advent of the Early Bird communication satellite in 1965 stimulated considerable interest in the subjective effects of circuit delays, and of the echo-suppressors which had to be fitted in order to attenuate the return signal. During the first six months of the Early Bird satellite, a sample of the customers who had made calls between the United Kingdom and the U.S.A. were interviewed by being called back and asked whether they had experienced any difficulty in conversing. (Karlin J.E. 'Measuring the acceptability of long-delay transmission circuits used during tne 'Early Bird' transatlantic tests in 1965', PTT Bedriff, 1967, and Hutter J. 'Customer response to telephone circuits routed via a synchronous-orbit satellite', Post Office Electrical Engineers Journal, 1967).

(67) 'The economic factors involved are often substantial, a signal-to-noise improvement of a few decibels in a national telephone or television network to give greater customer satisfaction may cost some millions of pounds to achieve in practice' (Bray W.J. 'Human Factors Research in the British Post Office', 5th Symposium on Human Factors in Telephony, London 1970).

(68) In research at the Post Office Research Department, Dollis Hill, the speed with which pairs of subjects connected by telephone completed a simple problem solving task was taken as an index of 'message rate efficiency'. Message rate efficiency was defined as the ratio of the time required with a good connection, to that needed for a given connection, with 95% on this criterion taken as the point at which performance has been impaired. However, impairment has only been observed when circuit quality falls to 'poor or bad', and Richards concludes that connections beyond this point are virtually useless for telephony. A graph showing the points at which different methods of assessment begin to take effect is reproduced overleaf as Figure 2. It is reproduced from a paper by Mr.D.L.Richards on 'Communication by speech - the important factors in telephony' presented at a number of centres during 1969 and 1970 on behalf of the Institution of Post Office Electrical Engineers.

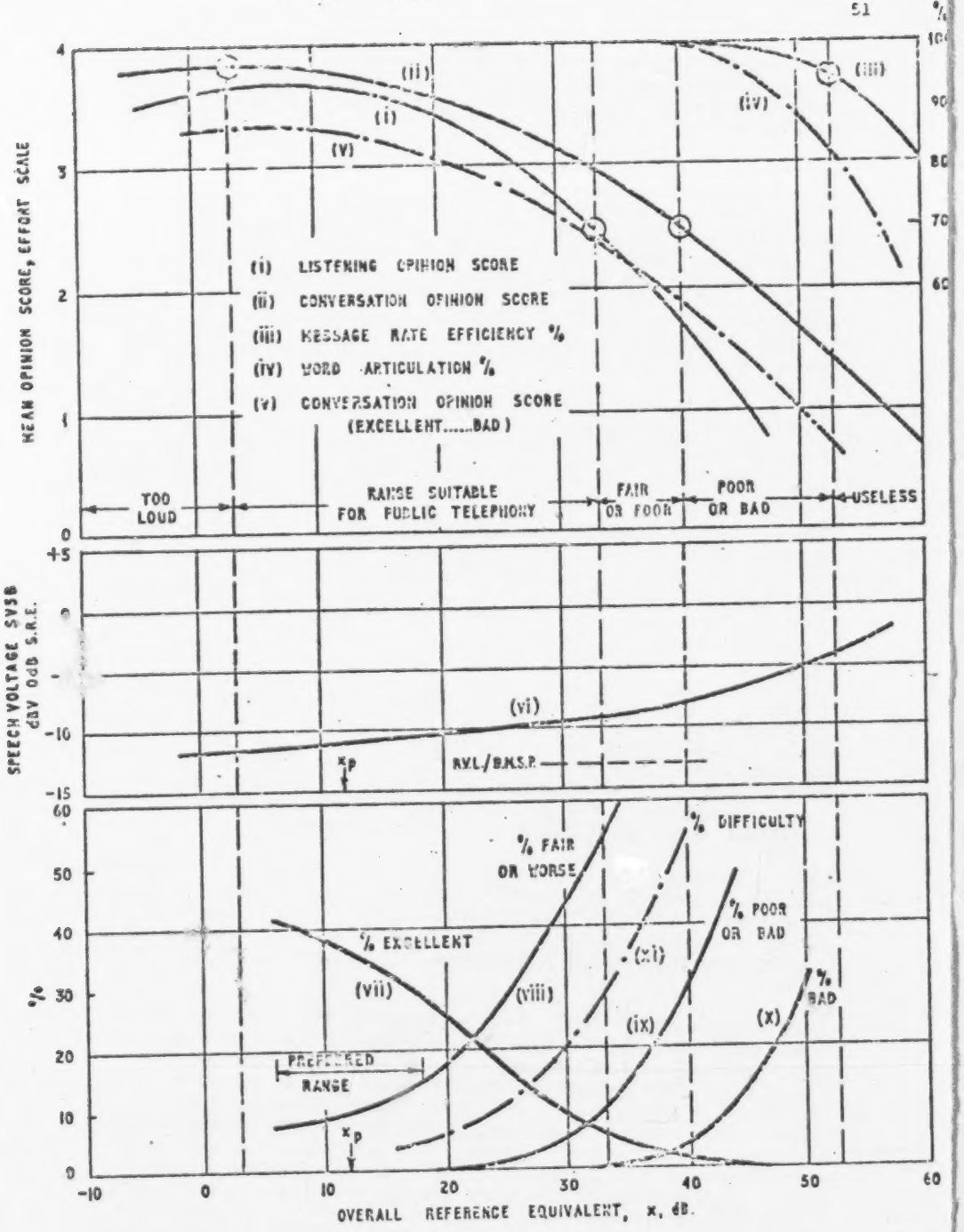


FIG. 3. ASSESSMENTS OF TELEPHONE CONNEXIONS ACCORDING TO VARIOUS CRITERIA

ROOM NOISE 50 dB

CIRCUIT NOISE NEGLIGIBLE

(69) The effects of previous experience on categorical judgements are discussed by Duncanson, of Bell Laboratories, in a paper to the 5th Symposium on Human Factors in Telephony ('Context Effects in Categorical Judgements'). He writes that 'The experiences a person has with something such as telephone connections form some sort of distribution with respect to the aspect of the experience being judged, for example, transmission quality. That is, the person may experience all good (or all bad) connections; he may experience predominantly good (or bad) connections, but also a few bad (or good) ones; or the connections he experiences may be distributed normally or uniformly over a wide or narrow range of quality. All of these aspects of the distribution of previous experience have been found to influence a person's judgement of a current object.'

(70) There was good agreement between the questionnaire and observational data, except in certain specific categories. Respondents appeared to underestimate the amount of time spent in face-to-face communication and overestimate the amount of time spent reading and writing. The observational data showed the sample as dividing their time in the following way: talking face to face 35%; telephone 7%; reading 12%; writing 14%; working with laboratory equipment 13%; working with office machines 3%; other activities 15%.

(71) Research and development laboratories have provided a fertile ground for communication surveys. Allen, of the Sloan School of the Massachusetts Institute of Technology, has been responsible for a number of studies in this area. He has a particular interest in the way in which 'technological gatekeepers' transmit information from the environment to the organisation, and in the characteristics of these individuals. One example of his published work is Allen T.J. & Cohen S.I. 'Information Flow in Two R&D Laboratories', Administrative Science Quarterly, XII, March 1969. Some similar work is now being undertaken at the Manchester Business School.

(72) All travel between all 15 locations was measured for all Bell Laboratories personnel for one month. Each traveller was given a questionnaire concerned with the various details and purposes of his trip. The questionnaire included questions on the physical details of the journey, the initiation of the journey, purpose of the journey, and the use of visual aids at the destination. Information concerning job type, base location, and status within the organisation was already available.

(73) 'A research program designed to study the effect of mode, including everything from a computer printout to face-to-face contact, on receiver behaviour, receiver attitudes, and the information content of the data received is now underway' (Conrath D.W. & Johnson G. 'Organization Communication and Structure: an exploration', Systems Engineering Report, Bell Canada Northern Electric Research, February 1971).

(74) For such a review, see the five-volume 'Handbook of Social Psychology', edited by Lindzey G & Aronson E. (Addison-Wesley Publishing Company, second edition 1969). The volumes cover the following fields: 1. Systematic positions. 2. Research methods. 3. The individual in a social context. 4. Group Psychology and Phenomena of Interaction. 5. Applied Social Psychology.

(75) (McGrath J.E. & Altman I. 'Small Group Research; a synthesis and critique of the field', Holt, Rinehart and Winston, Inc. 1966).

(76) (Argyle M. 'Social Interaction', Methuen, 1969).

(77) The two items which have the distinction of being common to both books are: Bartlett Sir F.C.'Remembering: a Study in Experimental and Social Psychology', Cambridge University Press, 1932; and Davitz J.R. (ed), 'The Communication of Emotional Meaning', McGraw-Hill, New York, 1964.

(78) When gaze-direction is measured during experimentally created two-person conversations, it is found that the proportion of time each person looks at the other may vary from 0 to 100%, though it typically lies between 25 and 75%. The person listening gives longer glances than the one talking, and tends to look considerably more. Exline found that people tended to look more at a person they liked, or if they were high in affiliative motivation (Exline R.V. 'Explorations in the process of person perception: visual interaction in relation to competition, sex and need for affiliation', Journal of Personality, 31, 1963; Exline R.V., Gray D. & Schuette D. 'Visual behaviour in a dyad as affected by interview content and sex of respondent', J.pers.soc.Psychol., 1, 1965; Exline R.V., & Winters L.C. 'Affective relations and mutual gaze in dyads' in S.Tomkins & C.Izzard (eds.) 'Affect, Cognition & Personality', Springer, 1965). Exline also found that if the amount of subjects' looking was measured after they had been involved in a deception, those subjects that were high on 'Machiavellian rating' maintained the amount of their looking, but other subjects reduced it (Exline R.V. et al 'Visual interaction in relation to machiavellianism and an unethical act', Amer.Psychol. 16, 1961).
Argyle has found an inverse relationship between amount of looking and physical proximity. Subjects took part in three-minute discussions with stooges trained to stare, at distances of two, six and ten feet. The amount of eye contact increased markedly with distance, the greatest rise being between two and six feet (Argyle M. & Dean J. 'Eye-contact, distance, and affiliation', Sociometry, 28, 1965).
Kendon found, from the analysis of films of two-person conversations, that people tend to look up towards the end of long utterances, the hypothesis being that this is the point at which they require most feedback from the listener. Conversely, he found that people tend to look away just prior to starting long utterances, and during hesitations and unfluent passages, the hypothesis here being that by looking away he can gain time for planning what he has to say, by forestalling any attempt to speak by the auditor. (Kendon A. 'Some functions of gaze direction in social interaction', Acta Psychologica, 26, 1967).

(79) In observational studies Scheflen found high consistency in the use of postures such as sitting back in a chair. He also found that predictable postural sequences preceded the entry of a member of a group into the conversation. (Scheflen A.E. 'The significance of posture in communication systems', Psychiatry 27).
Birdwhistell is best known for his notation of facial movements and expressions. This requires the transcription of the subject's facial expressions by a trained observer. He reported in 1952 a study which showed subjects' ability to distinguish 11 distinct positions of the eyelid (Birdwhistell R. 'Kinesics and communication', Beacon Press, 1952). His 1968 notation system involved 4 eyebrow positions, 4 eyelid positions, 7 mouth positions, with 33 positions in all (Birdwhistell R., 'Kinesics' in International Encyclopedia of the Social Sciences, 8, 1968.)
Ekman & Friesen argue that non-verbal cues are particularly relevant in a deception situation, where they tend to 'leak' information which the speaker is trying to conceal. The hypothesis has only been tested

with psychiatric patients (Ekman P. & Friesen W.V. 'Nonverbal Leakage and Clues to Deception', Psychiatry, Vol.32, No.1, 1969).

(80) Mehrabian has carried out a number of investigations of the distances and stances adopted by standing communicators. He reviews his own and other work in the area in 'Significance of Posture and Position in the Communication of Attitude and Status Relationships' (Psychological Bulletin, Vol.71, No.5, 1969). He concludes that distance, eye-contact, body orientation, arms-akimbo position, and trunk relaxation have been found most consistently to be indicators of communicator attitude towards an addressee; and that these variables, together with the degree of arm openness of female communicators and degree of asymmetry in the arrangement of arms and legs have been found to be associated with status relationships with the addressee.
Hall found that in the United States distances of from 6 to 18 inches are typical for intimate interpersonal situations, distances of from 30 to 48 inches are typical of casual-personal interaction, distances of from 7 to 12 feet are characteristic of social-consultative situations, and distances of 30 feet and more are characteristic of public interaction situations. The features of these various distances are described in more detail in note 44 above. (Hall E.T. 'The Silent Language', Fawcett, 1959).
Gofrman, in his book 'The Presentation of Self in Everyday Life' (Anchor Books, 1959) studies interpersonal communication from the perspective of the theatrical performance, a perspective which necessarily has much to do with posture, position, and spatial arrangement. His later book 'Behaviour in Public Places' is particularly concerned with the postural and gestural procedures by which individuals move from 'unfocused interaction' (ie. presence in the same place) to 'focused interaction' which is 'concerned with clusters of individuals who extend one another a special communication license and sustain a special type of mutual activity that can exclude others who are present in the situation'. (Goffman E. 'Behaviour in Public Places', The Free Press of Glencoe, 1963).

(81) Sumby & Pollack, who measured speech intelligibility scores for 129 subjects under face-to-face and back-to-back conditions found that their performance using a 256 word vocabulary was approximately 100% in each condition. Only when speech-to-noise ratio was reduced did the visual cues begin to make any measurable contribution to intelligibility (Sumby W.H. & Pollack I. 'Visual contribution to speech intelligibility in noise' J.acoust.soc.Amer., 26, 1954). Stapley found similar results in an experiment using television pictures instead of the face-to-face condition. He also found that an extremely abstracted image (formed by edge-detection techniques) was virtually as effective for lip-reading as was the full 625-line television image (unpublished PhD. thesis, Imperial College, London). The implication of these experiments is that a good voice channel is 100% effective for simple articulation tasks, and that more subtle tests will be required if differences are to be found between media.
In experiments by Eldersveld, people received four mailed appeals to vote in a forthcoming local election, or were contacted once by telephone or by a personal visit, or by mailed appeals and a visit, or were not contacted at all. In these studies, voting turnout was markedly higher among those receiving some form of personal contact than among those sent printed appeals or not contacted at all (Eldersveld S., 'Experimental propaganda techniques and voting behaviour', Amer.polit. Sci.Rev. 50, 1956).
In an experiment by Moscovici & Plon (1966) it was found that pairs of subjects sitting back-to-back or side-by-side spoke more in the written

style, compared with subjects sitting face-to-face, whether the latter could see each other, or were sitting on opposite sides of an opaque screen. This suggests that the change in speech patterns was a function not of the withdrawal of vision, but instead of the unfamiliarity of the first two conditions (Moscovici S. & Plon M. 'Les situations-colloques; observations theoretiques et experimentales', Bull. Psychol. 60, 1966).
Morley & Stephenson conducted bargaining exercises by subjects playing the roles of union and management negotiators, under varying communication conditions. The four conditions were: face-to-face (freedom to interrupt); face-to-face (no interruptions); telephone (freedom to interrupt); and telephone (no interruptions). The experimenters see these four conditions as lying on a scale of increasing 'formality' in that order. They found that the side with the 'strongest' case tended to have more bargaining victories in the more 'formal' conditions, and interpret this as indicating that the more 'formal' condition leads to a greater emphasis on inter-party exchange, and a lesser emphasis on interpersonal exchange (Morely I. & Stephenson G.M. 'Interpersonal and interparty exchange; a laboratory simulation of an industrial negotiation at the plant level' Br.J.Psychol. 60,4, 1969).
Sinaiko et.al. in their teleconferencing studies carried out for NATO at the Institute for Defense Analyses, studied the effect of varying the channel of communication on the conduct of international strategic bargaining tasks. They conclude that 'In conferences that are primarily negotiations, telephone is preferable to face-to-face meetings. Distractions are fewer and discipline is greater'. They suggest that teleconferences involving simply the exchange of information appear to be more effective via teletype than telephone, perhaps because writing is generally more precise than speech and because a recorded text aids memory. (Sinaiko W. et.al. 'Teleconferencing: summary of a preliminary research project', Study S-138, Institute for Defense Analyses, Research & Engineering Support Division, 1963).
Cook recorded laboratory conversations by 24 university students. Half conversed face-to-face, the other half conversed through a microphone/loudspeaker system. Although Cook found some differences in speech patterns between the two conditions (utterances were shorter, and there were fewer interruptions, in the no-vision condition), in many respects there was no variation between conditions. Thus, the number of 'filled pauses' (um, er, etc.) the number of 'attention signals' (mm, yes, etc.) and the speech rate were the same in each case. Nor did the no-vision condition make the subjects feel 'less comfortable', as expressed on a subjective rating scale (Cook M. 'Non-verbal signalling in social interaction', unpublished D.Phil thesis, University of Oxford).
In a series of experiments by Argyle, Lalljee & Cook, pairs of subjects were asked to converse under conditions of varying visibility (one or both wore dark glasses, face or body masks, or were separated by one-way or opaque screens). Early experiments indicated that ease of perception of the other, comfort, and ease of interaction, fell off rapidly with invisibility of the other. But when, in later experiments, no-vision and symmetrical reduced visibility conditions were introduced it was found that there was no evidence of difficulty of interacting.
Except in the trivial case of articulation tests under noisy conditions, and the special circumstances of the international strategic negotiation, no marked effects which can confidently be attributed to the medium of communication emerges from the studies which have been cited.

(82) Thus Shaw compared the ability of single individuals and four person groups in complex problem-solving tasks. She attributed the better performance of the groups to the fact that groups check their

solutions, and are prepared to reject incorrect solutions. (Shaw M.E. 'A comparison of individuals and small groups in the rational solution of complex problems', Amer.J.Psych. 44, 1932).

(83) Measures of performance in these experiments have been based on the time to solution, the number of errors, and the number of messages sent. It has usually been found that Wheel, Y, Chain, Circle, give a decreasing order of performance on all three measures. Most studies have shown that the higher the centrality of a position, the greater the satisfaction of the member holding the position, in terms of the job, the organisation, the solution and the other workers (Davies M.F. 'Co-operative problem solving in groups', Joint Unit for Planning Research, University College London, mimeographed). Early papers in this area are Bavelas A., 'Communication Patterns in Task-oriented groups', J.acoust.soc.Amer., 22, 1950; and Leavitt H.J. 'Some effects of certain communication patterns on group performance', Journal of Abnormal Psychology, 46, 1951.

(84) (Katz.D. & Kahn R.L. 'The Social Psychology of Organizations', John Wiley & Sons, 1966).

(85) (Deutsch K.W., 'On Communication Models in the Social Sciences', Public Opinion Quarterly, 16, 1952.

(86) (Katz D. & Kahn R.L. 'The Social Psychology of Organizations', John Wiley & Sons, 1966).

(87) Vide the studies of communication in R&D laboratories by Allen, of the Sloan School of Management, M.I.T., cited in note 71 above.

(88) Part of the recordings were based on self-observation, the sampling moments being indicated by a watch alarm that rang at random times, part were based on observations by a trained observer also at random times. Good agreement was obtained between the two methods. (Case Institute of Technology, 'An operations research study of the scientific activity of chemists', Operations Research Group, Case Inst. Techn., Cleveland, 1958.

(89) Hinrichs also used the pocket alarm method. He found that non-supervisory personnel spent 56% of their working time communicating, and that this percentage rose with rank to 87% for third-level supervisors. (Hinrichs J.R. 'Communications activity of industrial research personnel', Personnel Psychology, 17, 1964).

(90) (Stewart R. 'How Managers spend their time', Management Today, June 1967).

(91) (Palmer A.W. & Beishon R.J. 'How the day goes', Personnel Management, April 1970).

(92) Palmer and Beishon write that 'One interesting feature of the records obtained lies in the length of sequences which can arise from purely chance encounters. It is not uncommon to find that a large part of the day is taken up by a series of events which happen solely because each event in the series is determined by chance encounters. This is best illustrated by an example: If a manager goes to seek someone else he frequently meets other people on the way. Occasionally one of these meetings leads him to go to another place he was not intending to visit; while he is there he encounters another person who may take him to yet another place, such as the shop floor. He may be caught up in this random sequence - where his

next activity is determined by where he is - for some time before he can 'reset' himself and again start doing something he has planned ahead'.

(93) Among Burns' conclusions are that:
1. The group overestimated the time it spent on production and underestimated the time it spent on personnel, indicating an unawareness of the extent of its absorption in internal problems of 'human relationships'.
2. Most of the interaction of the executives inside the department was internalized within a staff group of about fourteen; and two-fifths of it was further internalized within the executive group itself.
3. There was a marked tendency for interaction to be initiated downwards rather than upwards.
4. Within the executive group itself, discrepances in referring interaction episodes to subject divisions occurred in a third of the cases - according to how the situation was perceived in terms of the role of the participant.
5. Discrepancies also occur regularly in the perception by subordinates of communication as conveying information or advice in contradistinction to what superiors intended as instructions or decisions. The operation of a mechanism of status protection may be inferred.
(Burns T., 'The directions of activity and communication in a departmental executive group', Human Relations, Vol 7, 1954.)

(94) Weinshall's principal findings were that in the organisation under study only 25% of the perceived interactions among the participating management group were mutually acknowledged; that is to say, 75% of the perceived interactions did not register in the minds of the other party. From among the mutually perceived interactions, less than 50% of the communications 'went through', ie. there was a consensus as to the type of interaction. In all, only 12% of the perceived interactions 'went through'. (Weinshall T.D. 'The Communicogram' in J.R.Lawrence (ed), 'Operational Research and the Social Sciences', Tavistock Publications, 1966).

(95) Hesseling's techniques are described in Hesseling P. 'Communication and Organization Structure in a Large Multi-National Company', in Heald G. (ed), 'Approaches to the Study of Organizational Behaviour', Tavistock Publications, 1970.

(96) (Graves D. 'Authority and Organization Structure in a French and English Management System', London School of Economics, mimeographed).

(97) Conrath reports that the data has been collected, and is now being processed. A copy of the contact diary that was used is reproduced in Conrath D.W. & Johnson G. 'Organization Communication and Structure: an exploration', Systems Engineering Report, Bell Canada Northern Electric Research, February 1971.

(98) (Hansen D.A. & Parsons J.H. 'Mass Communications: A Research Bibliography', The Glendessary Press, Santa Barbara, 1968).

(99) (Lasswell H. 'The Structure and Function of Communication in Society', in Berelson & Janowitz, 'Reader in Public Opinion & Communication' (first published 1948).

(100) For example Warner's study of the roles of the Vice-President in charge of news, the Executive Producer, the Washington Bureau Chief, the Associate Producer, the News Editor, and the Newscaster, the writers, copy editors, and reporters of the major American TV networks. (Warner

M. 'TV Coverage of International Affairs', Television Quarterly, VII, 196[illegible]).

(101) See for example the March 1971 staff report and recommendations by the Division of General Research, Philadelphia City Planning Commission. Stress is laid in the report on the need to arrange, through cable TV, for the provision of educational, health, and library services, and methods by which residents can learn about and participate in decisions related to their particular communities within the city. (Philadelphia City Planning Commission, Division of General Research, 'Planning for Cable Television for Philadelphia', March 1971, mimeographed).

(102) (Berelson B. 'Content Analysis in Communications Research', Free Press, New York, 1952).

(103) This bibliography, by Prof.F.E.Barcus, then of Boston University, is available from University Microfilms Inc., Ann Arbor, Michigan.

(105) A typical sociogram was generated by Coleman et.al. ('Social processes in physicians' adoption of a new drug', Journal of Chronic Diseases, 9, 1959). Each of nine medical doctors in one community were asked to name the doctors with whom they most frequently discussed their cases. Doctor no.5 was the key opinion leader in this clique. He was reported as a discussion partner by all eight of his colleagues. Doctor no.6 had somewhat less opinion leadership, being named by three others.

(106) The two-step flow of mass communication was first hypothesised by Lazarsfeld P.F. et al ('The People's Choice', Duell Sloan & Pearce, 1944) who found, in their study of the 1940 Presidential campaign, that vote decisions, particularly among the late deciders, were dominated more by active personal influence and face-to-face communications than by the mass media. This led them to conclude that 'ideas often flow from radio and print to opinion leaders and from these to the less active sections of the population'.
Weiss ('Effects of the Mass Media of Communication', in Lindzey G. & Aronson E. 'The Handbook of Social Psychology' Addison Wesley, 1969), discusses a number of reasons why interpersonal contact should be more effective in this respect than the mass media. He points out that the communication process can be timedpropitiously; attention is assured and miscomprehension can be minimised; appeals can be developed to fit the salient motivations of the recipient, etc. But like Rogers, he suggests that the 'two-step' notion is too simple, and that influence should properly be regarded as passing through several levels of personal relationships. (Rogers E.M. 'Diffusion of Innovations', The Free Press, New York, 1962).

(107) Methods of audience research in current use in the U.K. are described by Tunstall in the introduction to his book on 'Media Sociology' (Constable, 1970). They include the television ratings organized by JICTAR - a committee including advertising agencies, the independent television companies, and the advertisers. This service uses meters attached to TV sets in 2,650 households. And the National Readership Survey organised by JICNARS - a similar committee for the newspaper industry. This survey involves a random national sample of 30,000 individuals a year, and is designed primarily to establish the readership of national newspapers and magazines. The British Broadcasting Corporation operate a Survey of Listening and Viewing, which involves 2,250 interviews every day.

(108) (Weiss W., 'Effects of the Mass Media of Communication', in Lindzey G. & Aronson E. 'The Handbook of Social Psychology', Addison-Wesley, 1969).

(109) Weiss points out that almost none of the experimental work has examined the cumulative or long-term effects of repeated exposure to displays of aggression. He argues that it is in the slow cumulation of effects brought about by voluntary exposure in the normal environment to a variety of programmes depicting violence that the mass media are likely to have an influence on aggressive motivations and behaviour (Weiss W., op.cit.).

(110) (Emmett B.P. 'The Design of Investigations into the Effects of Radio and Television Programmes and other Mass Communications', Journal of the Royal Statistical Society, Vol.129, Part I, 1966). Mr.Emmett is currently head of BBC audience research.

(111) (Greater London Council, 'Greater London Development Plan: Report of Studies', 1969).

(112) The proposed urban motorway network for London would involve the displacement of around 15,000 homes.

(113) (National Academy of Engineering, Committee on Telecommunications, 'Telecommunications for enhanced metropolitan function and form', Report to the Director of Telecommunications Management, August 1969).

(114) (National Academy of Engineering and Connecticut Research Commission Joint Committee on Cities of the Future, 'An addendum to the Quarterly Report November 1970-January 1971, to the Department of Housing and Urban Development', mimeographed.). The primary interest of this subpanel is in the possibility of attracting employment to small towns, and new towns, by means of a broadband communications network.

(115) (Hagerstrand T. 'The propagation of Innovation Waves', Lund Studies in Geography, Series B, No.4, 1952; and Hagerstrand T. 'Innovation Diffusion as a Spatial Process', Chicago 1967). The second item, which is translated by Pred A.R., was originally published in swedish in 1953.

(116) (Brown L.A. 'Diffusion Processes and Location: a conceptual framework and bibliography', Regional Science Research Institute, Philadelphia, 1968.)

(117) Rogers identifies six major research traditions in the study of the diffusion of innovations. They are respectively anthropology, early sociology, rural sociology, education, industrial, and medical sociology. He argues that they entered the field in that order (Rogers E.M. 'Diffusion of Innovations', The Free Press, New York, 1962).

(118) (Kawaguchi, T. 'Statistical study of telegrams, telephones, and money orders as factors determining the sphere of influence of cities', Otsuka Geographical Papers, 1, 1936).

(119) (Green H.L. 'The Geographic use of point-to-point telephone call data', Annals of the Association of American Geographers, 43, 1953).

(120) (Gottman J. 'Megalopolis', Twentieth Century Fund, New York, 1961).

(121) (Ajo R. 'Telephone call markets', Fennia, 86, 1962).

(122) The findings are reported briefly in Thorngren B. 'How do contact systems affect regional development?', Environment and Planning, Vol.2,

1970. Thorngren's survey covered four towns: Stockholm, Gothenburg, Sundsvall, and Umea. It included some offices attached to manufacturing plants as well as central offices. The data comprises 8182 telephone calls and 2169 face-to-face meetings.

(123) The first full report of Goddard's survey was completed in May 1971, under the title 'Office Linkages in Central London'. It consists of two volumes, the first volume consisting of a spatial analysis of the location of office employment in Central London, the second consisting of a report of the contact diary survey.

(124) Latent Profile Analysis is a method of clustering the data into homogenous groups. It is akin to factor analysis, but instead of yielding factors it yields typologies, each type being represented by a specific average score on each of the variables. Unlike factor analsyis, latent profile analysis is not variance orientated or reductionist, searching to reduce the data into the minimum number of independent groups or factors. Rather, a group may be defined which includes a very small number of contacts simply because these represent a dense cluster of observations. (Goddard J. 'Office Linkages in Central London: Vol.II', London School of Economics). The technique of Latent Profile Analysis is described in Gibson W.A. 'Three multivariate models: Factor analysis, Latent Structure Analysis and Latent Profile Analysis', Psychometrika, 24, 1959.

(125) Goddard's contact diary, unlike Thorngren's, had a question on the main purpose of the meeting. The multiple choice categories were as follows: Give order or instruction; receive order or instruction; give advice; receive advice; bargaining; give information; receive information; exchange information; general discussion; other. The proportion of contacts involving the giving or receiving of orders or instructions was twice as great for telephone contacts as for face-to-face meetings (16% vs. 8%). (Goddard J. 'Office Linkages in Central London: Vol.II', London School of Economics, 1971).

PART 3: PRIORITIES FOR FUTURE RESEARCH

It was argued in Part I that policy for the future development of the person-person telecommunications system must rest on a thorough understanding of telecommunications needs, telecommunications technology, telecommunications effectiveness, and telecommunications impact.

An attempt was made in Part 2 to demonstrate that the necessary degree of understanding exists in only one of these areas, namely that of telecommunications technology.

It is the purpose of this part to make some specific proposals about the kinds of research which should be undertaken if the gaps in our knowledge are to be filled in.

My first general argument is that the vast bulk of telecommunications research is technological in orientation, and is therefore being directed at the very area about which we know most. This amounts to a wasteful misallocation of research resources, and some shift of effort away from technological research towards studies of the human aspects of telecommunications is therefore of the utmost importance.

My second general argument is that such research as has been undertaken on the human aspects of person-person telecommunication has generally been concerned with individuals as employees of organisations, rather than as citizens in their own right. This is another imbalance which should be corrected if telecommunications innovation is to serve the needs of the whole community, and not simply the needs of business.

I specifically propose that the following studies could be undertaken with advantage:

1. A programme to develop, and test, effective methods of surveying all forms of interpersonal communication, including face-to-face, telephone, and mail, so that a reliable and comprehensive picture of existing communication patterns may be established.

2. A programme to evaluate, by means of controlled laboratory experiments, the comparative effectiveness of a wide range of interpersonal communication media, when used for a variety of purposes.

3. A programme to evaluate, by means of field trials, the comparative effectiveness of a range of telecommunications systems.

3. A programme to evaluate, by means of field trials, the comparative effectiveness of a range of telecommunications systems.

4. A programme to maintain continuous observation of the commercial introduction of novel person-person telecommunications systems, so that users' reactions may be studied under real conditions.

5. A programme to develop mathematical models of the interaction between telecommunications technology and other aspects of the environment, such as location of employment and traffic patterns, so that the wider impacts of telecommunications innovation may be predicted.

6. A programme to investigate the extent to which handicaps such as isolation, immobility, loneliness, or old age, may be mitigated by the effective application of telecommunications technology.

Some work has already begun in each of these areas. In terms of U.K. costs $100,000 per annum put into a university research programme on any one of them would enable the existing work to be accelerated and extended, so that some real progress could be made. Given sufficient resources, several of the programmes could be tackled simultaneously. By comparison with the many million dollars per annum spent on technological telecommunications research, the outlay would be small. The return would be considerable.

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